OLDMAN RIVER DAM
WILDLIFE HABITAT MITIGATION
- VEGETATION ESTABLISHMENT -

Interim Progress Report
1990-91

A. SMRECIU and J. HOBDEN

Wild Rose Consulting, Inc., Edmonton
in co-operation with
Alberta Environmental Centre, Vegreville

Prepared for Alberta Public Works, Supply and Services
March 1991

OLDMAN RIVER DAM
WILDLIFE HABITAT MITIGATION
- VEGETATION ESTABLISHMENT -

Interim Progress Report
1990-91

A. SMRECIU and J. HOBDEN

Wild Rose Consulting, Inc., Edmonton
in co-operation with
Alberta Environmental Centre, Vegreville

Prepared for Alberta Public Works, Supply and Services
March 1991

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

The authors are grateful to Al Nilson of Alberta Public Works, Supply and Services for his guidance and enthusiasm throughout the year, and to June Carrington and Craig Osterloh for keeping us up to date on progress at various mitigation projects.

We would like to acknowledge the logistical support of the Alberta Environmental Centre (Vegreville). A special thanks to Reinhard Hermesh and Barbara Darroch for their valuable input, ongoing support, and continued patience. We are grateful to Zack Florence for his expert advice concerning experimental designs and statistical analyses. Thanks to Denise Burton and Leslee Porayko for their technical assistance.

Thanks to Alberta Environment (especially Mr. Dale Hay) for installation of the moisture tubes.

We are extremely grateful to Mr. Dave Hay for preparing and assisting in field arrangements.

1 INTRODUCTION

The Oldman River Dam, first announced in 1980, is being built in southwestern Alberta 10 km northeast of Pincher Creek, just east of the confluence of the Oldman, Castle, and Crowsnest Rivers (Figure 1), a site confirmed in 1984. The primary purpose of the dam and the resulting reservoir will be flow regulation and replenishing storage during maximum flow (mid-May to mid-July) to provide a dependable water supply throughout the year for domestic, municipal, industrial, agricultural, and recreational uses. Construction of the project began in 1986 and is expected to be complete in late 1991. Water was first stored in the spring of 1991. At full supply level, the reservoir will cover an estimated area of 2400 ha, and will be approximately 24 km long and up to 3 km wide. Water depths will exceed 60 m in some parts.

To cope with the environmental disturbances that would inevitably arise from the construction and eventual flooding, the Planning Division of Alberta Environment initiated studies which lead to Environmental Mitigation/Opportunities Plans for various aspects of concern including environment (wildlife and fisheries), historical resources, and recreation (Alberta Environment 1988a, 1988b).

Work began on the wildlife portion of the Environmental Mitigation/Opportunities Plan in 1985 and 1986 with a review of pertinent information, followed by field surveys of wildlife. A vegetation survey, conducted in 1984 and 1985, described major plant communities and discussed dominant factors controlling vegetation in the areas surrounding the future reservoir site (Hardy Associates (1978) Ltd. 1986). The report also included a brief reclamation plan and recommendations concerning procedures and methods for preserving and restoring native vegetation.

The Delta Environmental Management Group Ltd. (the Delta Group) was retained by Alberta Environment in 1987 to prepare a strategy for wildlife habitat mitigation at the Oldman River Dam Site. Their objectives were to:

> '...identify opportunities for wildlife habitat mitigation in the vicinity of the reservoir and, on the basis of this inventory, develop practical and effective projects to protect, enhance, or create wildlife habitat during 1988 to 1993.' (Green and Eccles 1989).

An action plan was formulated by the Delta Group in cooperation with Alberta Public Works, Supply and Services (APWSS) (Nilson and Green 1989). Projects were presented along with an implementation plan for wildlife habitat mitigation projects.

Three major mitigation techniques were recommended and are now being implemented. The first is **protection** of important wildlife habitat which already exists in the vicinity of the reservoir. This is being accomplished by acquiring both crown and private lands. The land base has been fenced to exclude grazing and other activities that would be detrimental to the native habitat. The second major method is habitat **enhancement**. This includes techniques undertaken to modify or improve sites to increase their use by wildlife. Enhancement included placement of snow fences to improve soil moisture and planting of trees and shrubs around existing wetlands and in other suitable areas. New wildlife habitats are also being **created** by construction of riparian dams and check dams and planting appropriate plant species (i.e. those which will provide erosion control and provide food and shelter for wildlife). Other projects involve creating or enhancing nesting sites for raptors, providing suitable structures for duck nesting sites and providing structures for other animals. These however, do not involve modifying vegetation and therefore will not be considered further in this report.

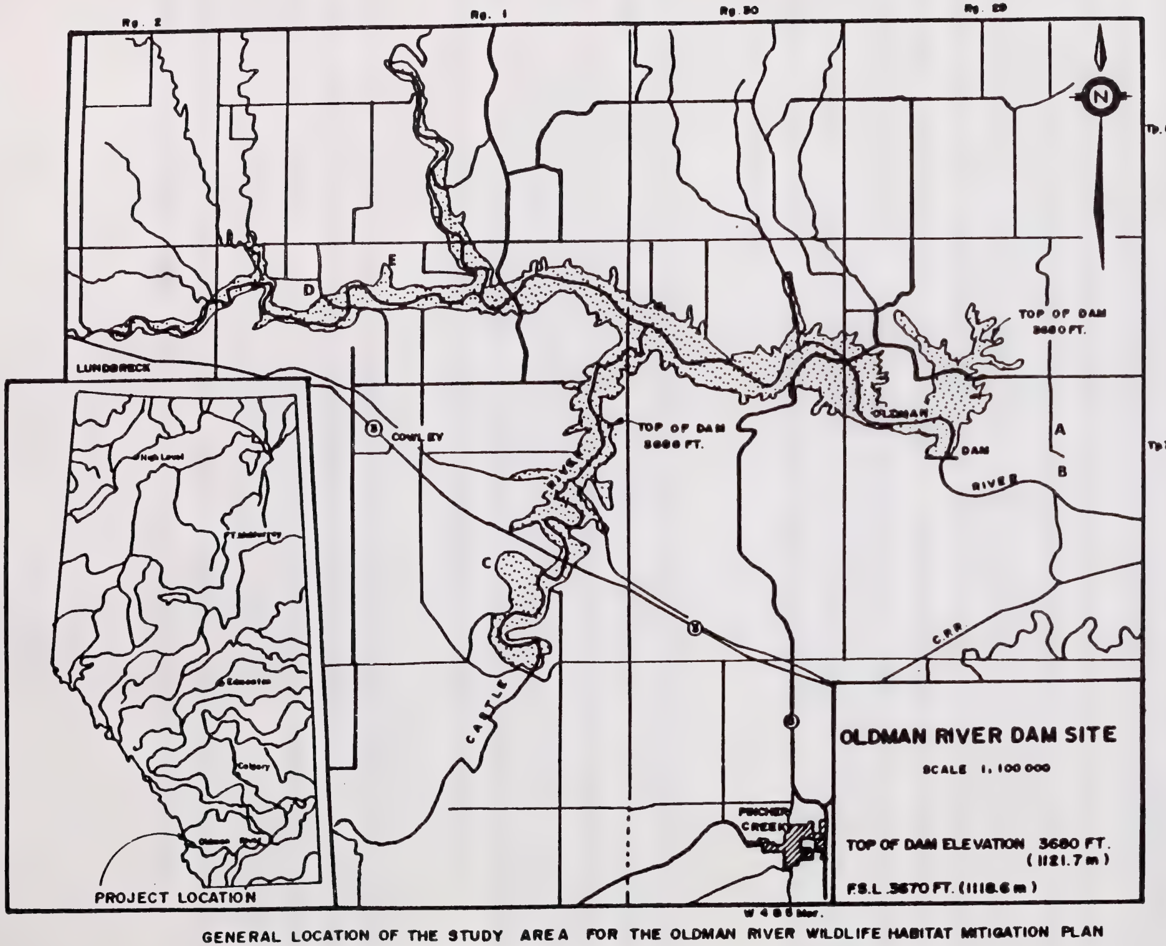
Since the objective of wildlife habitat mitigation is to provide wildlife with sufficient habitat to replace that being lost to flooding after 1991, the success of the program will be measured by the eventual use by wildlife and survival of wildlife after flooding. Success of many individual projects however, depends on establishment of specific (mostly native) plants and enhancement of specific vegetation. Success also depends on the potential for natural regeneration of improved vegetation. Only the vegetation aspects of specific projects are considered in results reported here.

Beginning in June of 1989, various mitigation projects at the Oldman River Dam site were surveyed and audited. Experimental programs were set up, in co-operation with Plant Sciences Division (Vegetation Branch) of Alberta Environmental Centre (AEC) in Vegreville, to evaluate and where necessary improve the effectiveness of existing methods of protecting and enhancing plant communities, to evaluate methods and species selection in the creation of new wildlife habitat, and to provide input into planning for supplemental and replacement plantings.

An Interim Progress Report was submitted to APWSS in March 1990 (Smreciu 1990). That report described the specific background, plans and experimental designs for projects which were started prior to 1989, and outlined those to be started in 1990.

This interim report consists of results from surveys of projects which were started prior to 1989, and the design and preliminary results of experiments started in 1990. Also included is a preliminary list of vascular plant species native to the area of the dam and reservoir and lists of voucher specimens and seed collected in 1989 and 1990. Scientific names used in this report follow Moss (1983), Smreciu and Currah (1989), and Aiken and Darbyshire (1990).

Figure 1. Location of study plots at the Oldman River Dam Site.



A. Shelterbelt and nursery plantings

B. Snow fence effects on tree and shrub encroachment

C. Soil moisture behind snow fences

D. Grassland recovery

E. Grassland restoration

2 MITIGATION PROJECTS

The following is a brief description of the monitoring and experimental projects which have been set up in the land base around the Oldman River Dam site and presents the interim results from the monitoring of each in 1990. Figure 1 illustrates the location of each project on-site.

2.1 Auditing Existing Mitigation Projects

2.1.1 Shelterbelt and nursery plantings

Background: In 1987 and 1988 a major tree planting scheme was undertaken on a site east of the dam (PROJECTS OS26 (Sec 21, Twp 7, Rg 29, W4M) and OS17 (Sec 16, Twp 7, Rg 29, W4M)). Numerous snow fences were erected and trees were planted on the leeward sides and supplied with moisture through a drip irrigation system. Most of the site had been previously cultivated and has been seeded to native and introduced forage grasses. Small areas closer to the river valley had not been cultivated and trees planted in this area were planted in narrow trenches cut into the native grassland. Shelterbelt plantings were placed to reduce soil erosion and provide shelter for wildlife. Survival of trees was not recorded in 1987 and 1988. In 1989, 10 plots were designated and the number of live and dead trees were counted in each plot. Results in 1989 indicated that most of the trees were still alive but that the Colorado blue spruce (*Picea pungens 'glauca'*) and the Douglas fir (*Pseudotsuga menziesii*) were in poor shape and continued survival was doubtful. The demise of these trees was probably due to winter desiccation and the alkalinity of the soil. The caragana (*C. arborescens*) had survived from 1988 when many had been replanted, however severe insect damage had occurred especially on those planted into the native range or in areas where the introduced forage grasses had become established. Northwest poplar had survived but some damage had been caused by deer browsing.

Monitoring survival and growth of these trees is being done every two years therefore no monitoring was undertaken at this site in 1990. Monitoring will continue in 1991.

2.1.2 Snow fence effects on tree and shrub encroachment

Background: Coulees, on the north side of the future reservoir and oriented in a north-south direction, have limited numbers of trees and shrubs, most of which grow on the east face where they are protected from wind, and in the bottom of the coulees where moisture collects. At the top edge of the coulees shrub communities are sharply differentiated from the surrounding grassland

community because there is no longer protection from the drying winds and soil moisture is reduced. Since shrubs and trees provide better cover and browse for wildlife than grasslands, snow fences were erected in the fall of 1988 (by APWSS) at a site to the north and east of the dam, within the protected land base (PROJECT OS17 (Sec 16, Twp 7, Rg 29, W4M)). Snow fences were placed along the ridges between the coulees to encourage the encroachment of trees and shrubs from the coulee up into the grassland. In 1989 five transects were set up from a NW-SE fence line to the edge of the shrub communities. Two were placed where there was snow fence, two were in an area with no snow fence and one was placed in a transition area along each transect. A permanent plot was placed at the edge of the shrub community and three more plots were set up at 2 m intervals from the first. The objective of this audit was to monitor shrub encroachment from the coulee slopes to the adjacent grassland when snow fences are placed along the top of the coulee slope. The relative abundance of vascular plant species will be determined each year and compared to determine if the area covered by shrubs is increasing. Records were taken in 1989 as a baseline.

Results (1990): Data collected in 1990 are presented in Table 1. Observations taken in 1990 indicate a marked increase in the relative abundance of both grasses and forbs in most of the plots (with the exception of the forbs in plots of Transect E). Much of this increase is likely due to the differences in precipitation (in amounts and the timing of the rainfall) between 1989 and 1990 (Appendix 1). Some of the increase is due to the protection offered by the snow fences. The decrease in forbs in Transect E plots could be a result of the increase in grass cover.

After only one year there is little indication of increasing shrub cover. Shrub encroachment is a long term effect and little change is expected over a period of one year.

Table 1. Vegetation cover in plots set up to determine if snow fence placement increases invasion of shrubs from coulee slopes into surrounding grassland.

Plot Number*	Shrubs (%)		Graminoids (%)		Forbs (%)	
	1989	1990	1989	1990	1989	1990
A-15m	0.0	0.0	26.0	45.0	5.0	18.0
A-17m	0.0	0.0	26.0	31.0	2.0	10.0
A-19m	3.0	10.0	19.0	40.5	3.0	6.0
A-21m	41.0	36.0	2.0	28.0	57.0	52.0
B-20m	0.0	0.0	9.0	20.0	8.0	15.0
B-22m	0.0	0.0	37.0	31.0	3.0	16.0
B-24m	18.0	40.0	21.0	45.0	6.0	18.5
B-26m	35.0	43.0	20.0	25.0	8.0	15.0
C-21m	0.0	0.0	11.0	33.0	16.0	18.0
C-23m	0.0	0.0	11.0	46.0	9.0	21.0
C-25m	0.0	0.0	6.0	15.0	22.0	37.5
C-27m	55.0	67.5	30.0	36.0	7.0	12.5
D-22m	0.0	0.0	35.0	36.0	17.0	19.5
D-24m	0.0	0.0	29.0	35.0	16.0	20.5
D-26m	0.0	0.0	45.0	31.5	15.0	11.5
D-28m	46.0	40.0	31.0	41.5	16.0	24.5
E-22m	0.0	0.0	12.0	35.0	25.0	11.0
E-24m	0.0	0.0	4.0	30.0	35.0	9.5
E-26m	0.0	0.0	9.0	53.0	36.0	9.0
E-28m	28.0	18.0	27.0	41.5	41.0	10.5

* A and B are snow fenced, C is in the transition zone and D and E are from areas with no snow fence. Distances indicated in the plot numbers are from the fence line.

2.1.3 Soil moisture behind snow fences

Background: Snow fencing was erected on a section of perimeter fence at a site west of the Castle River and south of Highway 3 (PROJECT C37 (Sec 11, Twp 7, Rg 1, W5M)) in the fall of 1988. The primary purpose was to increase soil moisture levels such that trees and shrubs planted as part of the wildlife habitat mitigation program would have an increased chance of survival. Snow fences were placed at intervals, and gaps were left to allow access to wildlife. The existing fence provided an opportunity to study the effects of snow fences on soil moisture and provide site specific information for planning tree and shrub placement in the future. An experiment was set up to determine if significant differences in soil moisture could be detected among areas behind the snow fences and the controls (areas with no snow fences). Comparisons were made for various distances from the fence (1 m, 2 m, 4 m, 8 m, 16 m, and 32 m), at various depths (15 cm, 30 cm, 45 cm, 60 cm, and 75 cm) and at two different times in the season (summer and fall). A hand auger was used to obtain soil samples at the various depths. The percentage soil moisture (by weight) was calculated.

First year results indicate that there was a significant difference in soil moisture between fenced and unfenced areas and that depth, distance, and season were also significant factors. Generally soils were drier at greater depths, although surface samples were drier than those taken just below surface. Soils farther from the fence line were moister due to water run-off down slope, away from the fenceline. The greatest increases in soil moisture due to snow fences were at 2 m, 4 m, and 8 m from the fence (Smreciu 1990).

Moisture tubes were inserted in the ground in early summer of 1990 and soil moisture measurements were made with a Campbell Pacific (503) Moisture Gauge twice in the season (summer and fall) at depths of 0-15 cm, 30-45 cm, 60-75 cm, and 90-105 cm. Soil moisture results in 1990 were percentages by volume.

Results (1990): The surface soil moisture (depth 15 cm) was highest in the summer, behind the snow fences (Figure 2). At this depth the summer controls were higher than the fall snow fenced areas, which in turn were higher than the fall controls. Season had a greater influence on the soil moisture at 0-15 cm than did the effect of the snow fences. The effect of season is a reflection of the higher precipitation in July and August (summer) than in September (fall) (76.6 mm, 33.6

mm, and 10.2 mm respectively) (Appendix 1). Little change in soil moisture was recorded among distances at this depth.

At a depth of 30-45 cm results were similar, although overall moisture was somewhat higher (Figure 3). Down slope (at 24-32 m) in both summer and fall, the soil moisture of the controls slightly surpassed the snow fenced plots. This is probably an indication that the treatments were not independent (i.e. the effects of the snow fences placed on either side of the controls were influencing the controls) and soil moisture increased due to both slope and to snow catchment.

At 60-75 cm the snow fenced results for the fall surpassed those of the summer controls up to approximately 14 m from the fence line (Figure 4). Snow fences improved moisture to a great extent at this depth up to 14 m and the moisture was retained to some extent. At 90-105 cm, again soil moisture measured behind the fences surpassed those recorded in the controls in both summer and fall (Figure 5).

Although in 1989 soils were drier at greater depths (to 75 cm), in 1990 the trend reversed; the recorded soil moisture increased at greater depths to 105 cm especially those behind the snow fences, indicating a retention of soil moisture. A smaller increase was observed at greater depths in the controls.

Generally there were no differences in soil moisture among sampling distances. This is largely due to the slope on which these plots are located. There were greater differences between control and snow fenced sample sites closer to the fences. Moisture at 16 m and 32 m are not as affected by snow fences to the same degree as those at 1 m, 2 m, 4 m, and 8 m. This was largely because the gaps in the snow fences were small (approximately 13 m) and the effects of the snow fences fan out and overlap.

Measurements of soil moisture taken in established shrub communities at seven sites around the Oldman River Dam indicate that the moisture requirement for shrub communities is variable. Fall moisture readings in the shrub communities averaged 16% at 0-15 cm, 22% at 30-45 cm, 27% at 60-75 cm, and 30% at 90-105 cm. These moisture readings were not significantly different from those taken at seven grassland locations around the reservoir. The moisture measured in soils at Project C37 were comparable to those taken in native shrub populations such as saskatoon/choke

cherry, and Douglas fir around the reservoir in the summer and fall indicating there was sufficient moisture during these times to sustain native shrub communities. Spring soil moisture measurements and comparisons would be useful in determining if this aera could sustain a shrub community. There are also other factors such as protection from wind, and competition with other plants which would have an effect on shrub establishment in this (and other) areas.

Figure 2. Effects of snow fences on soil moistures (at 0-15 cm) in mid-summer and fall at seven distances from the fence line.

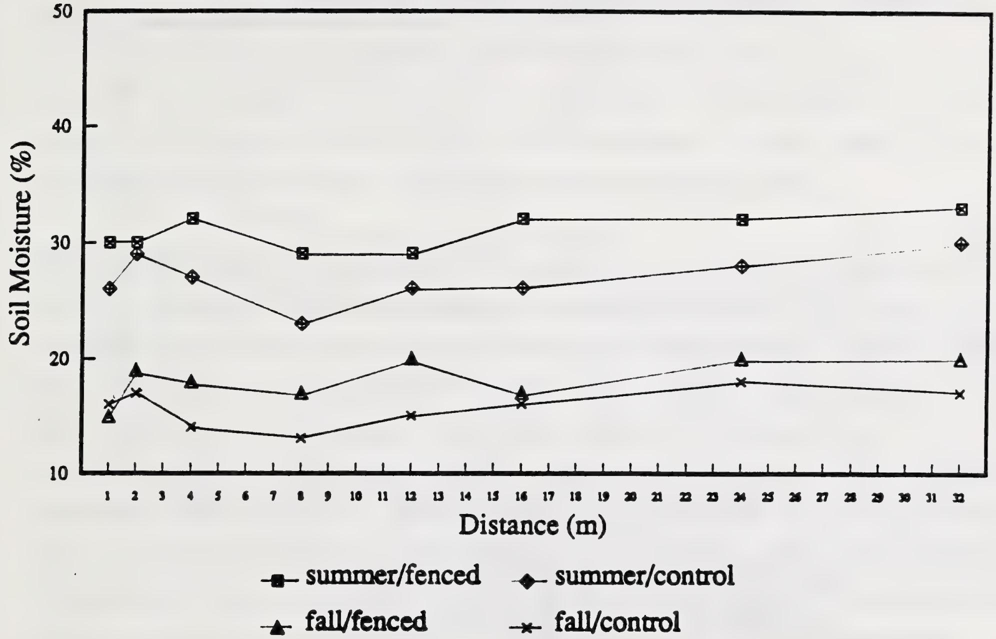


Figure 3. Effects of snow fences on soil moistures (at 30-45 cm) in mid-summer and fall at seven distances from the fence line.

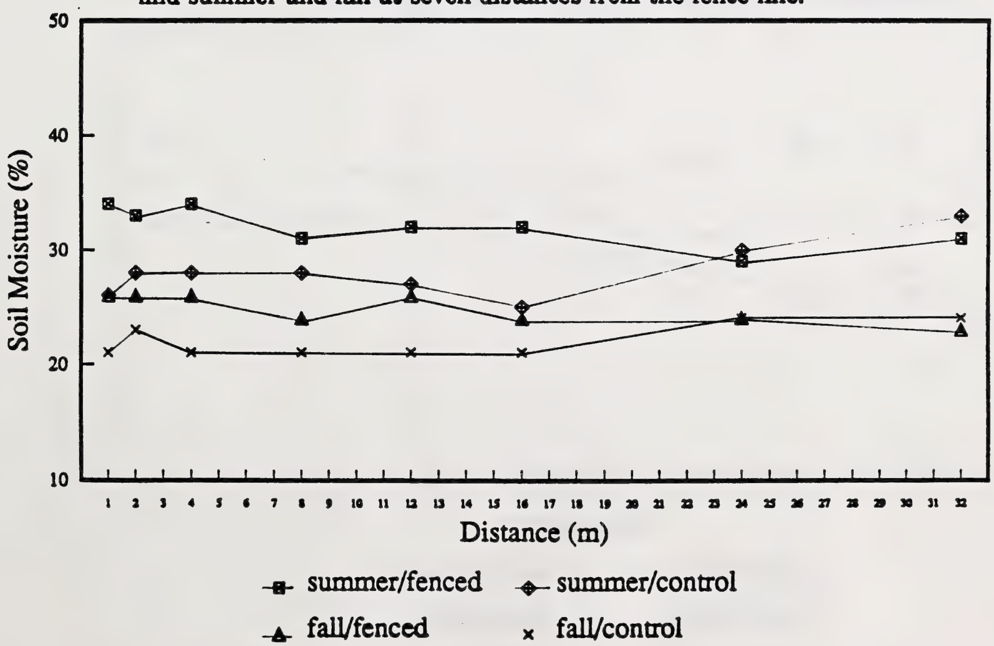


Figure 4. Effects of snow fences on soil moistures (at 60-75 cm) in mid-summer and fall at seven distances from the fence line.

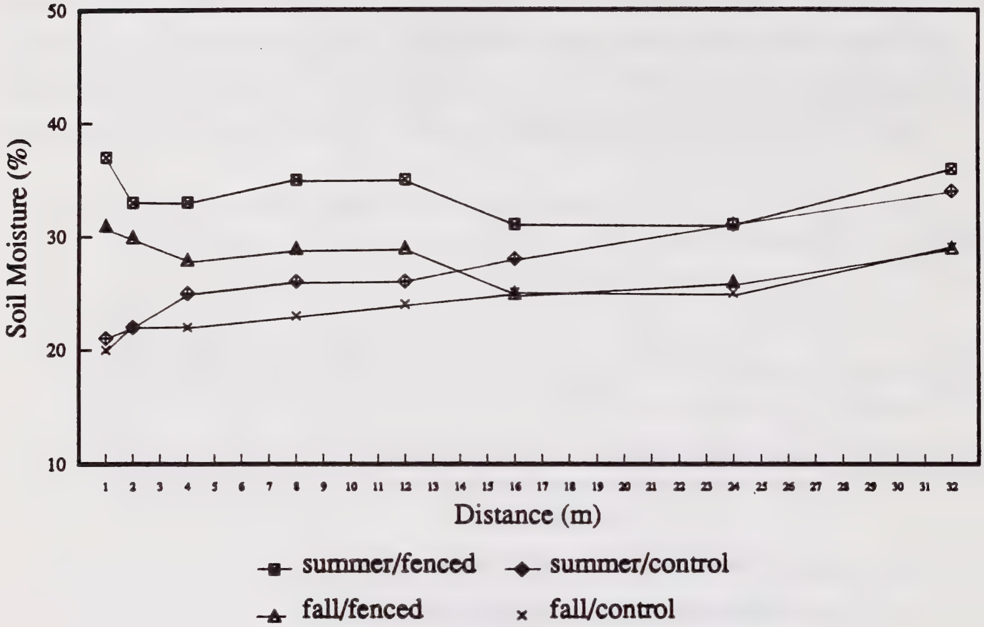
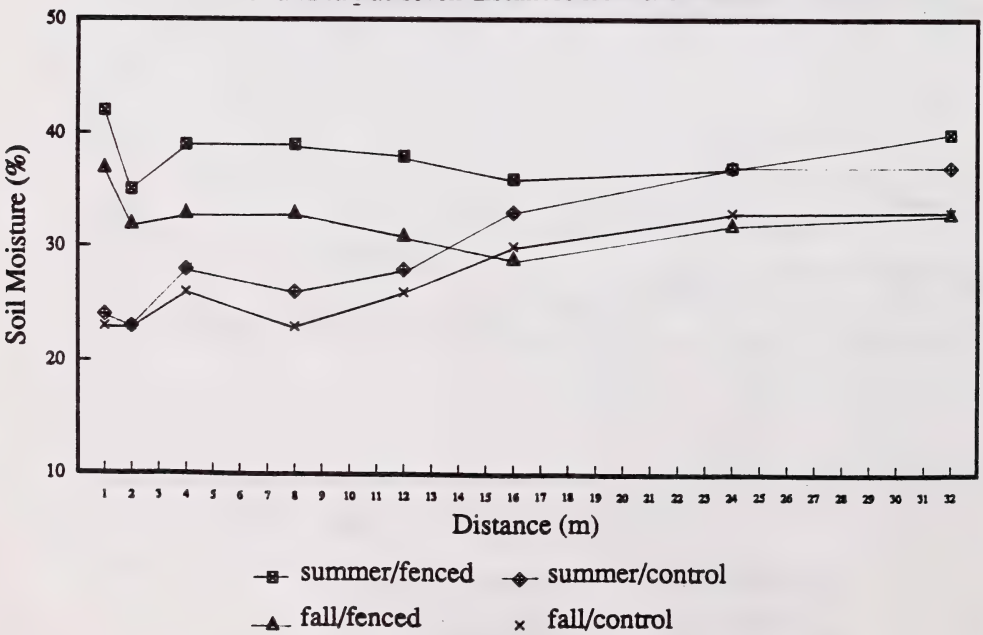


Figure 5. Effects of snow fences on soil moistures (at 90-105 cm) in mid-summer and fall at seven distances from the fence line.



2.1.4 Grassland recovery

Background: To improve the range for wildlife an area of previously grazed native rangeland was protected from grazing beginning in 1989 (PROJECT CR17 (Sec 32, Twp 7, Rg 1, W5M). In spring of 1989 six plots (each 2 m x 2 m) were placed in the protected area. These will be monitored over a period of at least three years for changes in species composition and relative abundance of individual species. Preliminary data were taken in 1989.

Results (1990): Relative abundance was recorded for each vascular plant species in each of the six plots. Results are presented in Table 2. One of the differences from 1989 to 1990 was an increase in the graminoid cover and an increase in the number of grasses observed in many of the plots. There was little change in the shrub cover. The elimination of grazing gave the grasses a short-term, competitive advantage. Due to the growth habit of shrubs, changes in shrub cover will only be observed after several years. There were some differences in the forbs which were observed in 1990. In plots 2, 3, and 6 there was an increase in the forb cover, and overall there were several species observed in 1990 which were not in 1989. Some differences observed between 1898 and 1990 were likely due to changes in precipitation (Appendix 1). Continued monitoring will be required prior to analysing data for compositional and abundance differences.

Table 2. Species cover in grassland recovery plots.

Taxa	Cover					
	Plot 1 (%)	Plot 2 (%)	Plot 3 (%)	Plot 4 (%)	Plot 5 (%)	Plot 6 (%)
Shrubs						
Rosa arkansana	1	t*	5	2	1	0
Symphoricarpos occidentalis	0	0	17	0	0	0
Graminoids						
Agropyron smithii	1	10	1	5	25	25
Agropyron spicatum	5	0	0	0	1	0
Agropyron subsecundum	0	0	1	0	0	0
Carex sp.	0	2	0	5	3	1
Danthonia parryi	15	5	20	t	t	t
Festuca campestris	10	t	15	1	0	1
Koeleria macrantha	15	20	3	30	10	15
Stipa curtiseta	2	1	t	15	2	1
Forbs						
Achillea millefolium	t	0	2	0	0	5
Agoseris glauca	t	0	0	0	0	0
Allium cernuum	0	t	1	0	0	0
Allium textile	0	0	t	0	0	0
Anemone multifida	0	0	t	0	0	0
Antennaria parvifolia	20	5	0	8	5	5
Artemisia campestris	t	0	t	0	t	0
Artemisia frigida	10	10	4	5	10	8
Aster ericoides	1	5	8	5	4	3
Aster laevis	1	0	0	0	0	0
Astragalus flexuosus	0	0	t	t	0	5

* t = < 1%.

Table 2. Species cover in grassland recovery plots.

Taxa	Cover					
	Plot 1 (%)	Plot 2 (%)	Plot 3 (%)	Plot 4 (%)	Plot 5 (%)	Plot 6 (%)
Astragalus dasyglottis	t*	0	0	0	0	0
Cerastium arvense	2	0	1	0	0	0
Cirsium undulatum	0	t	0	0	0	0
Comandra umbellata	0	t	0	0	t	t
Cryptantha nubigena	0	1	0	0	0	0
Erigeron caespitosus	1	t	t	0	0	0
Gaillardia aristata	t	t	1	t	1	t
Galium boreale	2	0	2	0	3	t
Geum triflorum	0	3	5	0	0	0
Heterotheca villosa	t	2	0	0	0	0
Heuchera parvifolia	0	0	0	t	0	0
Liatris punctata	2	3	0	t	3	0
Lithospermum ruderale	5	0	2	t	10	5
Orthocarpus luteus	t	0	5	0	t	1
Oxytropis monticola	1	0	0	0	0	0
Oxytropis sericea	1	t	t	t	0	0
Penstemon procerus	0	0	t	0	0	0
Petalostemon purpureum	1	1	0	0	0	0
Phlox hoodii	1	3	5	8	2	0
Potentilla concinna	0	t	0	0	0	0
Potentilla hippiana	t	t	t	0	0	0
Potentilla pensylvanica	t	0	t	t	0	t
Senecio canus	0	0	5	0	5	0
Solidago missouriensis	0	0	5	0	5	0

* t = < 1%

Table 2. Species cover in grassland recovery plots.

	Cover					
	Plot 1 (%)	**Plot 2** (%)	**Plot 3** (%)	**Plot 4** (%)	**Plot 5** (%)	**Plot 6** (%)
Sphaeralcea coccinea	0	0	0	0	0	1
Vicia americana	t*	0	0	t	0	0
Ruderals						
Erysimum inconspicuum	0	0	0	t	1	t
Taraxacum officinale	t	0	0	0	0	0
Tragapogon dubius	0	t	0	0	0	0

* t = < 1%

2.1.5 Grassland restoration

Background: An experiment was designed and set up in 1989 to study the effects of snow fences on the recovery of heavily grazed grassland. Although snow fencing was the primary factor being studied the experiment was designed to look at several other factors including direction from fences (windward/leeward), distance from the fences (2 m, 4 m, 8 m, 16 m, and 32 m) and their effects on the above-ground biomass of vascular plant species over six years. The field design of the experiment was presented in Smreciu (1990) and a diagram is included here for reference (Figure 6).

In 1989, prior to snow fence placement, above-ground biomass data were gathered and analysed. No statistical differences in total above-ground biomass were apparent among the plots. Snow fences were placed in October, 1989.

In 1990 biomass was cut in late August and early September and dried until mid-September when dry weights were recorded. Results were analysed and compared to those collected in 1989. Relative abundance and species composition were recorded for each vascular plant species in one sub-plot of each of the control and snow fenced plots in both 1989 and 1990.

In 1990 a second experiment was added onto the original design. This second experiment was set up to study the effects of snow fences on soil moisture at the Oldman River Dam Site. In early summer, soil moisture tubes were placed to one side or the other of the strips of plots and also at distances of 12 m and 24 m. Soil moisture was measured (using a Campbell Pacific (503) Moisture Gauge) in mid-summer and in the fall. Data were analysed using a GLM and an LSD test (SAS Institute 1988).

Results (1990): As expected there were significant differences between above-ground biomass data collected in 1989 and those recorded in 1990 (Table 3). There was a significant increase in total biomass throughout the entire experiment due in part to the differences in precipitation recorded in the region between 1989 and 1990 (i.e. there was greater rainfall during May, a time of active growth for many plants, in 1990 then in 1989) (Appendix 1). The remaining differences were attributed to the elimination of grazing from this area in 1990 and the placement of snow fences in late 1989 after baseline data had been collected.

Since there were highly significant differences in biomass from 1989 and 1990 these were analysed separately. As reported last year there were no differences among the different treatments in 1989 (Smreciu 1990). This was to be expected since no treatments had been started when the initial biomass was clipped.

Biomass data collected in 1990 were analysed and a highly significant difference was observed between data collected from the windward side of the fence line and those collected from the leeward side of the fence line (Table 4). Further analysis of data from the windward plots indicated that differences between snow fenced and control plots were not significant, and although differences between the biomass at different distances varied, no significance was found among that data either.

Analysis of above-ground biomass collected from leeward plots indicated that neither distance nor snow fences were significant factors, but there was a significant interaction between the two factors (i.e. at some distances the snow fences had an influence on the amount of biomass). When the means for the snow fenced plots and the control plots were plotted against each other at each of the distances (Figure 7) we see that the reason for the interaction is that the treatments were not independent. The effect of snow fence seems to be wider as distances from the fence line increased and there is an area of overlap beyond 16 m.

Where snow fences were placed there was a peak biomass at approximately 4 m from the fence line and this dropped off to 32 m. Although differences in biomass among the various distances were not significant, when monitored for several years these differences might become more pronounced. In the control plots (those where no snow fences were placed) the biomass is low at the 2-4 m distances but increases toward the 16 m distance and then levels out somewhat toward 32 m from the fences. The increase in the biomass at 16 m indicates the overlap of effects from the fenced areas as mentioned above.

An interesting drop in biomass is apparent at 2 m on the windward side of the fence line. This reduction in biomass is probably due to damage caused by the construction of the fence (i.e. vehicle movement along the fence line). It is interesting to note that the effect is much reduced where snow fences are in place.

Biomass data for grasses only were similar to those for the total biomass (Figure 8). Windward and leeward results for grasses were significantly different from each other (Table 5).

Whereas on the windward side of the snow fence there was no significant difference in **total biomass** between fenced and control plots there was a significant difference in **grass biomass** between fenced and control plots on the windward side (Table 6). Differences among distances (windward, fenced) were not significant.

Leeward of the fence line there was greater grass biomass than on the windward side however, no significant differences were found between fenced and control plots. As with the windward results there was some variation in the amount of herbage recorded at different distances but these had no statistical significance (Figure 8).

A drop in grass biomass, similar to that observed in the total biomass results, was recorded at 2 m from the fence on the windward side but **only** in the controls. This suggests that the grasses were able to recover more quickly that the forbs and shrubs but only when sufficient moisture was available (see discussion below regarding soil moisture responses to the snow fences).

No significant differences were observed for the biomass data for forbs or shrubs. These plants comprised a smaller portion of the vegetation and therefore relatively large changes due to snow fence placement would have to be recorded before results would be significant. These plants also take longer than grasses to respond to changes in soil moisture because of their growth habits. Forbs have long root systems which absorb moisture from greater depths than grasses and are somewhat more determinant in the number of shoots which can be produced as a response to moisture in a single year. Shrubs, because of their woody habit require a longer period to increase their above-ground component. The biomass of each of these groups is not tied to annual moisture cycles to the same extent as is the grass biomass. Perhaps over time differences among these groups will be observed due to the effects of the snow fences.

Soil moisture measurements taken at this site were analysed at each of four depths (0-15 cm, 30-45 cm, 60-75 cm, and 90-105 cm). The primary effect on soil moisture at 0-15 cm was season, and the effect of season diminished at greater depths; at 90-105 cm seasonal effects were not

significant. Season had a significant effect on soil moisture at 30-45 cm and 60-75 cm although the effect of snow fence was greater. As depth increased the effect of season diminished and the effect of the snow fences increased (Table 7). The effects of direction and distance also increased at greater depths. The great changes in soil moisture observed between summer and fall at 0-15 cm (Figure 9) were due to the effect of local precipitation, temperature, and drying winds. Soil moisture recorded at 90-105 cm did not change from summer to fall because there was no influence at this depth from the local daily and monthly climate changes.

Since our primary interest lies in the change in soil moisture due to snow fences (not seasonal changes) the results for the 0-15 cm depth are disregarded in these discussions. The summer moisture was greater than the fall readings at depths of 30-45 cm and 60-75 cm and remained constant at the 90-105 cm depth. We are interested especially in how much moisture is retained in the soil and therefore the fall data were analyzed in greater detail.

When only the fall data were analysed, both snow fence and direction were found to be significant factors at all three depths. The snow fence and direction effects increased with increased depth and at 90-105 cm distance and interactions of distance x fence and distance x direction were significant. Since direction was highly significant in the analysis of the fall data (at each of the three depths), data for each direction (windward and leeward) were analysed separately. Figures 10-12 are graphs comparing fall soil moisture data from the controls with the snow fenced data at each depth (30-45 cm, 60-75 cm, and 90-105 cm).

Analysis of the leeward data at 30-45 cm showed that the snow fence had a significant effect on soil moisture and at 60-75 cm and 90-105 cm the effect was highly significant. Analysis of leeward controls (areas with no snow fences) indicated there were no differences in soil moisture among various distances from the fence line at any of the three depths. For the areas where fences were placed, soil moisture did not vary significantly among distances at 30-45 cm or 60-75 cm leeward of the fence line, but it did vary significantly among distances at 90-105 cm.

Windward of the fence line, snow fences increased soil moisture significantly only at 60-75 cm and 90-105 cm. At 90-105 cm there was also a significant interaction between fence and distance (the snow fences had an effect on soil moisture at some distances).

There was no significance among distances for the controls (windward) at any of the three depths. There were however, significant differences among distances for all three depths, for the snow fenced results. At 30-45 cm the highest moisture were measured at 2 m and 4 m. This was also the case for depths of 60-75 cm and 90-105 cm (Figures 10-12).

In summary, the soil moisture (1990) was greater on the leeward side than on the windward side of the fence line. On the windward side soil moisture was significantly greater in the snow fenced areas than in the controls at depths of 60-75 cm and 90-105 cm. In the control plots, no significant differences were observed among various distances from the fence line, but in the snow fenced plots there were significant differences among distances from the fence line at all three depths. The greatest moisture were observed at 2-4 m from the fence line. Leeward of the fence line, significant differences were observed between control and snow fenced plots. There were no significant differences in soil moisture among distances for the controls and among snow fenced areas, distance was only significant at the 90-105 cm depth.

Greatest soil moistures were recorded at 90-105 cm at distances of 2-8 m behind the snow fences. A similar trend was apparent for the 60-75 cm and 30-45 cm depths but the actual moisture percentages were lower in each case.

In both soil moisture experiments we found that the moisture which is accumulating behind the snow fences is being retained at the 90-105 cm depth. At both sites we found that the accumulated soil moisture behind the snow fences compares favourably with soil moisture measured in shrub communities around the Oldman River Dam site (see page 9).

Figure 6. Field design of experiment to determine effects of snowfence on soil moisture and above-ground biomass.

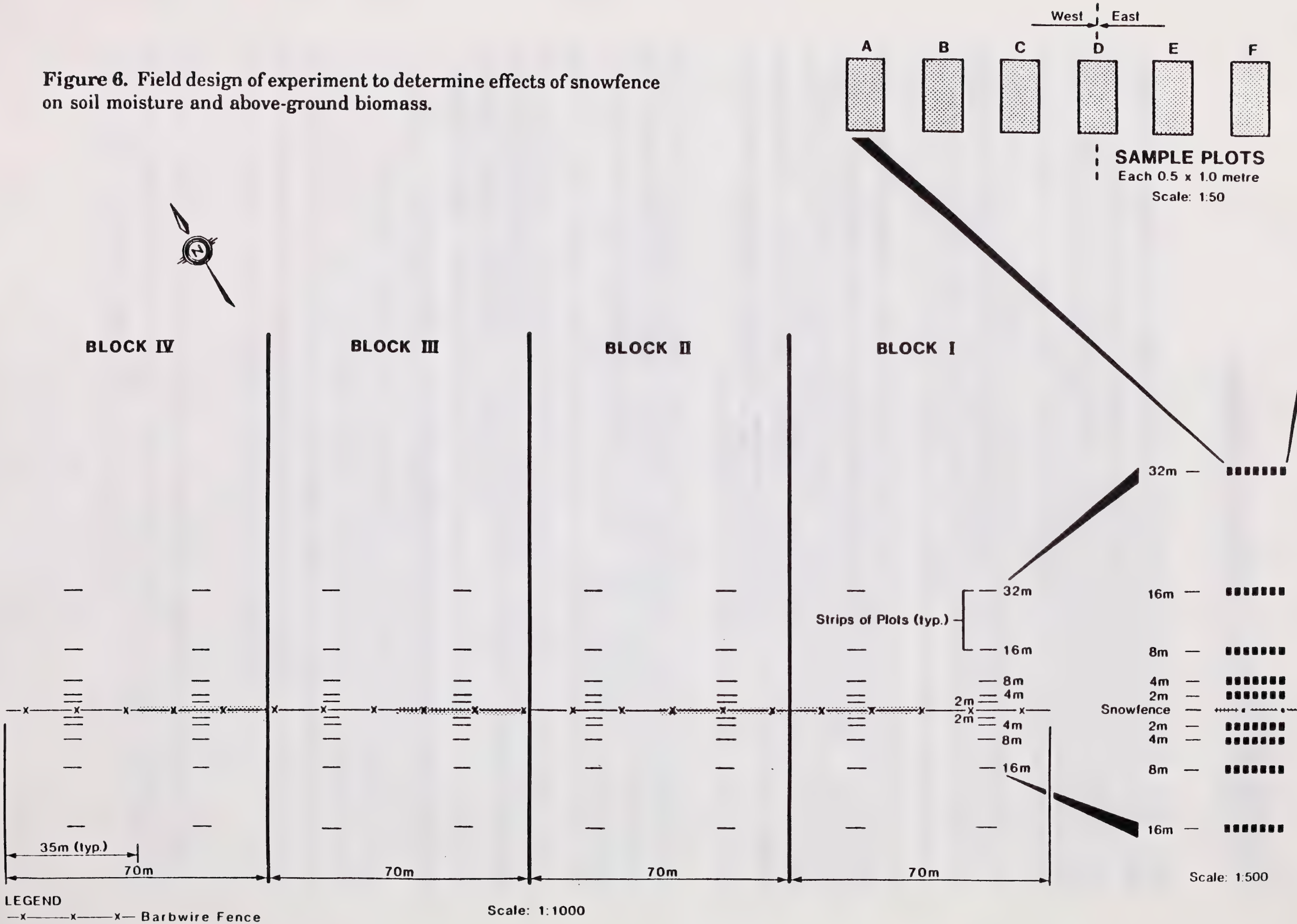


Table 3. Average total productivity in 1989 and 1990.

Year	Above-ground biomass* (g)
1989	70 a
1990	146 b

* Means followed by the same letter are not significantly different (LSD).

Table 4. Effect of direction from fence line on productivity (1990).

Direction	Above-ground biomass* (g)
Leeward	158 a
Windward	135 b

* Means followed by the same letter are not significantly different (LSD).

Table 5. Effect of direction from the fence line on grass productivity (1990).

Direction	Above-ground biomass* (g)
Leeward	117 a
Windward	103 b

* Means followed by the same letter are not significantly different (LSD).

Table 6. Effect of snow fence on grass productivity windward of the fence line (1990).

Treatment	Above-ground biomass* (g)
Fenced	110 a
Control	95 b

* Means followed by the same letter are not significantly different (LSD).

Figure 7. Effects of snow fence on total above-ground biomass at five distances in each direction (windward and leeward) from the fence line.

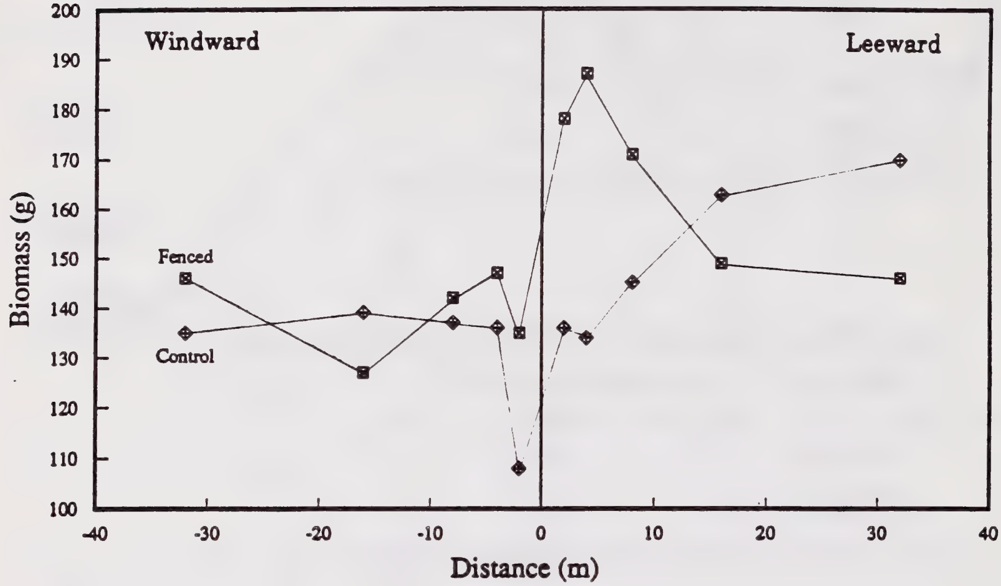


Figure 8. Effects of snow fence on above-ground biomass of grasses at five distances in each direction (windward and leeward) from the fence line.

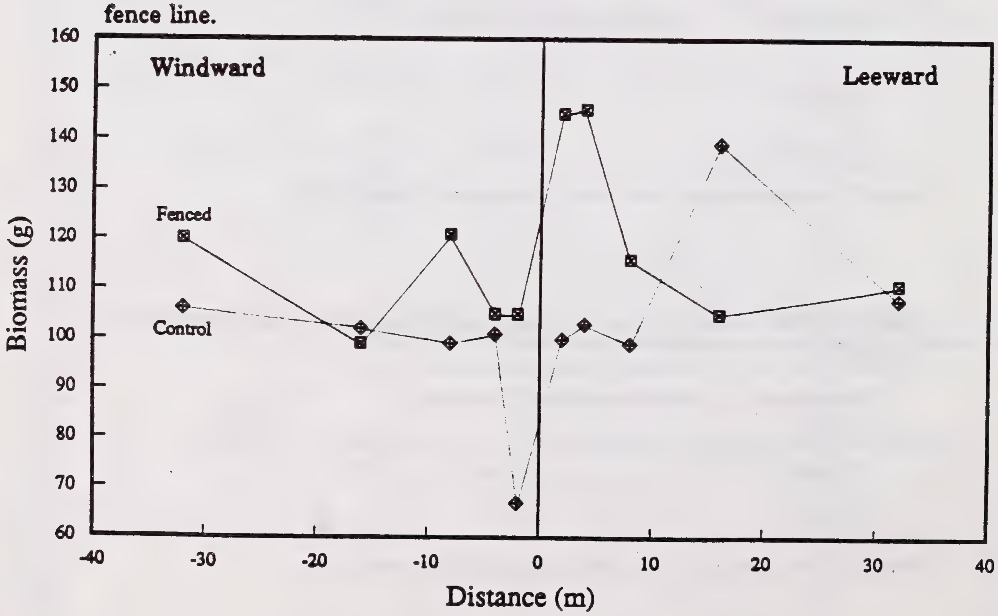


Table 7. Mean squares (MS) of each of the primary effects for soil moisture analysis at each of four depths.

Source	DF	MS 0-15 cm	MS 30-45 cm	MS 60-75 cm	MS 90-105 cm
Season	1	5286.56*	430.12*	883.19*	16.10
Fence	1	128.17*	1400.72*	3638.91*	5246.06*
Direction	1	0.94	628.81*	1212.39*	1651.31*
Distance	6	6.46	58.14	248.36*	413.71*

* significant at 0.1%.

Figure 9. Effects of snow fences on fall soil moisture at 0-15 cm, at seven distances, leeward and windward of the fence line.

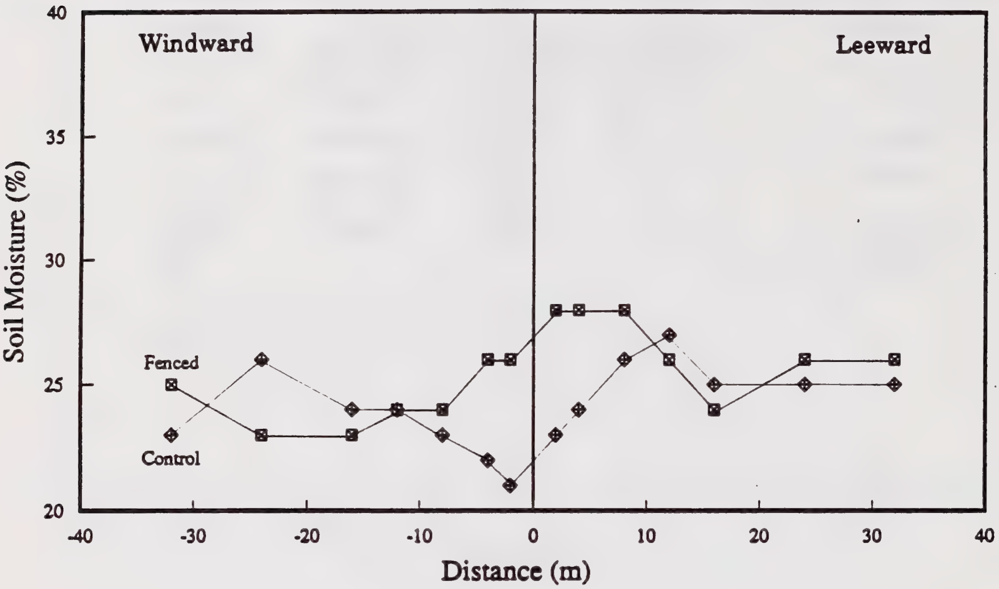


Figure 10. Effects of snow fences on fall soil moisture at 30-45 cm, at seven distances, leeward and windward of the fence line.

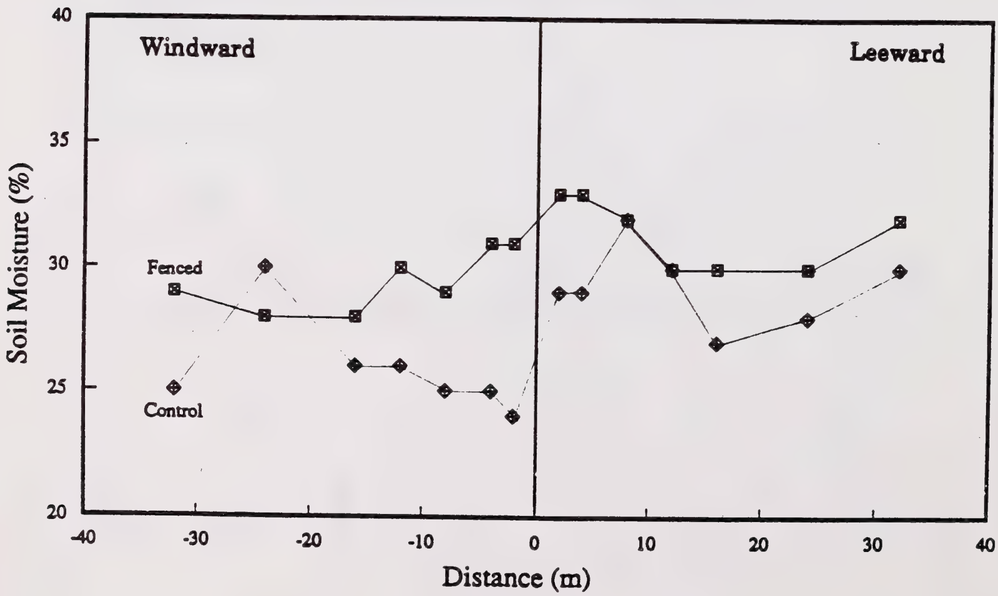


Figure 11. Effects of snow fences on fall soil moisture at 60-75 cm, at seven distances, leeward and windward of the fence line.

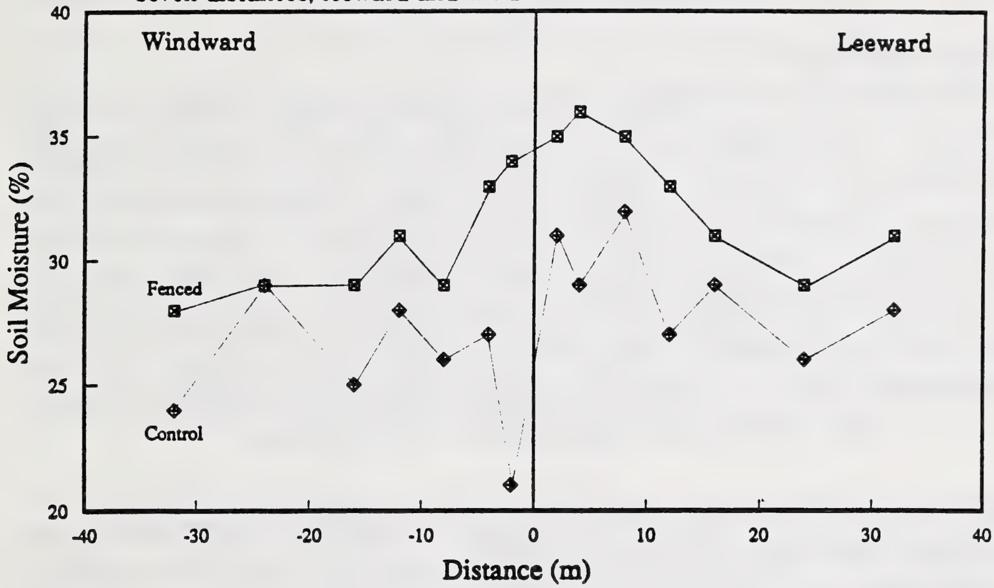
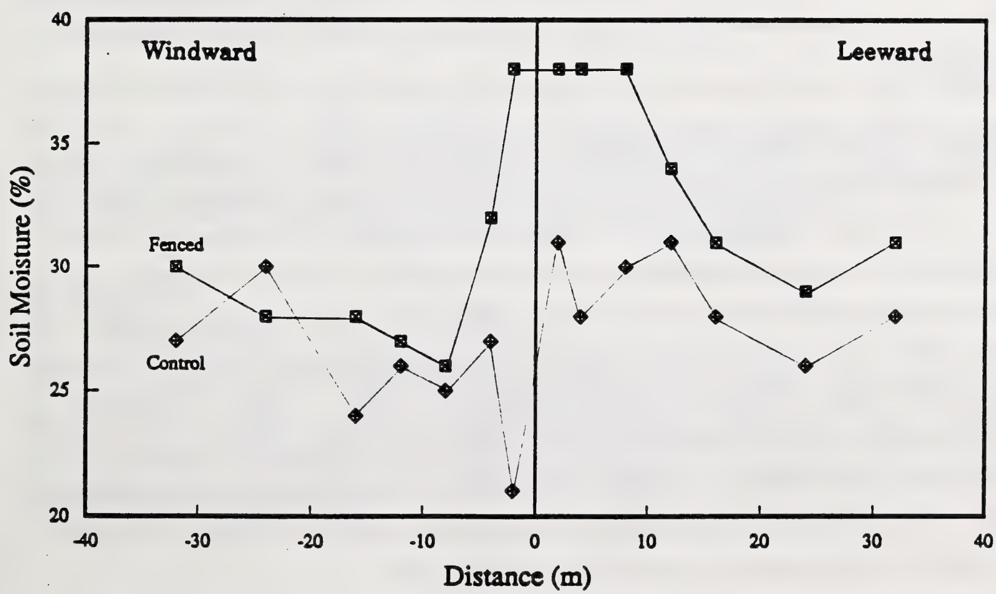


Figure 12. Effects of snow fences on fall soil moisture at 90-105 cm, at seven distances, leeward and windward of the fence line.



3 SPECIES DOCUMENTATION AND SEED BANK

3.1 Species Documentation

A list of the vascular plants of the Oldman River Dam land base is being prepared to determine if there are any rare or endangered species in the land base which must be protected, to identify any species which may be lost due to changes in habitat resulting from the construction of the dam, and to have available for future projects in restoration and revegetation a true reflection of the native vegetation. A preliminary list is included in Appendix II. Voucher specimens were collected and a set will be deposited with the herbaria at the Native Plants Genetic Resources Laboratory (AEC), the Provincial Museum of Alberta (PMAE), and the Oldman River Dam Interpretive Centre. To date, 132 species have been collected (Appendix III). Collection of voucher specimens will continue in 1991 and the Vascular Plants list will be updated.

One hundred and eighty three native plant species have been identified within the land base at the Oldman River Dam. There are another 14 which were reported by Hardy Associates (1986) but which have not yet been collected on-site. These may occur in nearby areas off-site since their study area was larger than the current land base. Voucher specimens were not collected therefore identifications of these species cannot be verified. We have identified 22 species which are introduced. These in most cases are weedy and present some problems for the reestablishment of native plants.

Three species have been found at the Oldman River Dam site which are considered rare in Alberta: *Androsace occidentalis, Hymenopappus filifolius* and *Penstemon eriantherus* (Wallis 1987, Wallis et al. 1987, Packer and Bradley 1984). Southwestern Alberta is the northern and western limit of the range over which *A. occidentalis* is found. It is also rare in British Columbia, and to the east in Iowa, Illinois, and endangered in Indiana. This species is however, common in the rest of its range which extends from southern British Columbia, east to western Ontario, and south to California, New Mexico, Texas, and Arkansas (Wallis et al. 1987). On site, *A. occidentalis* is locally scattered under mature Douglas Fir and was found south of Horseshoe Canyon. It will probably survive if left undisturbed although continued heavy grazing in this area may lead to the destruction of this species in the Oldman River Dam land base. Survival could also be in question if the Douglas Fir communities are lost (e.g. due to erosion, etc.).

Both *P. eriantherus* and *H. filifolius* are western species which reach their northern limits in southern Alberta. The former is also rare in British Columbia, Washington, and has a limited western range that includes Idaho, east to North Dakota, Nebraska, and Colorado. *H. filifolius* is native to south Saskatchewan, south to Oregon, Colorado, Kansas, and Mexico (Wallis et al 1987). In the Oldman River Dam land base this species is widely scattered in dry grassland, especially on southern exposures around rocky outcroppings. It was found in an area downstream of the dam and will probably be unaffected by flooding but may be lost due to planned recreational activities in this area. *P. eriantherus* was found only on the south exposures of the hillsides above the work camp. Several plants have already been removed for camp expansion. Since this is the proposed area for a recreational trailer complex, some care must be taken to preserve this small population. Voucher specimens of *A. occidentalis* and *P. eriantherus* have been collected, however none were taken of *H. filifolius* due to the small number of individuals present.

Two other rare species have been reported by Hardy and Associates (1978) Ltd. (1986) on site: *Crataegus douglasii*, and *Osmorhiza chilensis*. The latter is a widespread species which approaches its northwest range limit in Alberta. It is rare in Ontario and South Dakota; uncommon in New England, and threatened in Wisconsin but occurs from southern Alaska, British Columbia, south to California, Arizona, Colorado and east to Newfoundland and south to New England (Wallis et al. 1987).

Alberta represents the northern range of *C. douglasii*. It is a western species with many disjunct populations east (western Ontario, Minnesota, and Michigan) of its range in northern and western North America (Wallis et al 1987). An attempt will be made to document both of these species in 1991 and provide information regarding their preservation in the land base.

3.2 Seed Bank

3.2.1 Seed Production

In 1989, the Vegetation Branch (AEC) set up a nursery to multiply seed of some of the native forbs and make them available for various mitigation projects at the Oldman River Dam site. The first crop was harvested in 1990 and will be used in the erosion control plantings being made on the downstream dam face in 1991.

3.2.2 Seed Collection

Seed of native grasses, forbs, and shrubs are being collected. These will be maintained at the Native Plant Genetic Resources Laboratory at AEC. Seeds will be multiplied and made available for reclamation projects at the Oldman River Dam site and will be available for future research and selection programs (either at AEC or by other agencies interested in similar goals). A list of the seed collections made in 1990 is included in Appendix IV.

4 REFERENCES CITED

Aiken, S.G. and S.J. Darbyshire. 1990. Fescue grasses of Canada. Ottawa. 113pp.

Alberta Environment. 1988a. Oldman River Dam. Wildlife. Oldman River Dam Project Office. Alberta Environment. Edmonton, Alberta. 6pp.

Alberta Environment. 1988b. Oldman River Dam. Vegetation. Oldman River Dam Project Office. Alberta Environment. Edmonton, Alberta. 6pp.

Environment Canada. 1989. Daily temperatures and precipitation records for Pincher Creek Airport (April-October, 1989). Unpublished.

Environment Canada. 1990. Daily temperatures and precipitation records for Pincher Creek Airport. Unpublished.

Green J.E. and T.R. Eccles. 1989. A strategy for wildlife habitat mitigation for the Oldman Reservoir. The Delta Environmental Management Group. Calgary, Alberta. Prep. for Alberta. 36pp.

Hardy Associates (1978) Ltd. 1986. Vegetation Inventory: Oldman River Dam. Prepared for Alberta Environment, Planning Division. Calgary, Alberta. 102pp.

Moss, E.H. 1983. Flora of Alberta. 2nd ed., revised by J.G. Packer. University of Toronto. 687pp.

Nilson, A.L. and J.E. Green. 1989. An action plan for wildlife habitat mitigation for the Oldman River Dam Reservoir. Prep. for Alberta Public Works Supply and Services. Edmonton, Alberta. 16pp.

Packer, J.G. and C.E. Bradley. 1984. A checklist of the rare vascular plants in Alberta. Provincial Museum of Alberta. Natural History Occasional Paper No. 5. 112 pp.

SAS Institute Inc. 1988. SAS/STAT User's Guide: Release 6.03 Edition. 1028 pp.

Smreciu A. 1990. Oldman River Dam, Wildlife Habitat Mitigation. Vegetation Establishment. Interim Progress Report 1989-90. Prep. for Alberta Public Works, Supply and Services. Edmonton, Alberta. 60pp.

Smreciu, E.A. and R.S. Currah. 1989. A guide to the native orchids of Alberta. University of Alberta, Devonian Botanic Garden. 62pp.

Wallis, C. 1987. The rare vascular plants of Alberta: Volume 2. A summary of the taxa occurring in the Canadian Shield, boreal forest, aspen parkland and grassland natural regions. Prep. for Alberta Forestry, Lands and Wildlife. 10pp.

Wallis, C., C. Bradley, M. Fairbarns, and V. Loewen. 1987. The rare flora of Alberta: Volume 3. Species summary sheets. Prep. for Alberta Forestry, Lands and Wildlife.

Appendix I. Climate information for Pincher Creek (1989-1990)*.

Month	Year	Total ppt. (mm)	Max. Temp. (°C)	Min. Temp. (°C)
January	1989	45.6	10.9	-35.0
February	1989	32.4	6.1	-40.1
March	1989	33.0	10.1	-35.1
April	1989	50.2	22.5	-10.5
May	1989	64.8	23.3	-4.1
June	1989	72.8	26.5	2.9
July	1989	73.2	29.8	3.2
August	1989	60.6	30.1	3.5
September	1989	36.8	25.5	-3.7
October	1989	18.2	20.9	-8.3
November	1989	31.3	14.4	-14.5
December	1989	21.7	10.2	-31.0
January	1990	12.4	6.5	-30.1
February	1990	30.6	11.4	-35.0
March	1990	17.6	16.3	-21.9
April	1990	55.0	20.0	-17.9
May	1990	119.8	23.1	-4.2
June	1990	33.8	29.2	0.8
July	1990	76.6	32.6	3.0
August	1990	33.6	32.0	4.4
September	1990	10.2	28.8	-2.2
October	1990	27.4	22.1	-10.7
November	1990	53.6	18.0	-21.2
December	1990	25.2	5.6	-37.1

*Environment Canada (1989, 1990).

Appendix II. Vascular Plants of the Oldman River Dam Site.

* = Introduced.
** = Sightings recorded by Hardy Associates (1978) Ltd. (1986).

Selaginellaceae	**Club-moss Family**
Selaginella densa Rydb.	Little Club-moss
Equisetaceae	**Horsetail Family**
Equisetum arvense L.	Common Horsetail
Polypodiaceae	**Fern Family**
Cystopteris fragilis (L.) Bernh.	Bladder Fern
Cupressaceae	**Cypress Family**
Juniperus communis L.	Ground Juniper
Juniperus horizontalis Moench	Creeping Juniper
Pinaceae	**Pine Family**
Pinus flexilis James	Limber Pine
Pseudotsuga menziesii (Mirb.) Franco	Douglas Fir
Gramineae	**Grass Family**
Agropyron dasystachyum (Hook.) Scribn.	Northern Wheat Grass
Agropyron pectiniforme R.& S.*	Crested Wheat Grass
Agropyron smithii Rydb.	Western Wheat Grass
Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch Wheat Grass
Agropyron trachycaulum (Link) Malte	Slender Wheat Grass
Bouteloua gracilis (HBK) Lag.	Blue Grama, Buffalo Grass
Bromus inermis Leyss.*	Awnless Brome
Bromus tectorum L.*	Downy Brome
Calamagrostis montanensis Scribn.	Plains Reed Grass
Danthonia parryi Scribn.	Parry Oat Grass
Elymus piperi Bowden	Giant Wild Rye
Festuca idahoensis Elmer**	Bluebunch Fescue
Festuca saximontana Rydb.	Sheep Fescue
Festuca campestris Torr.	Rough Fescue
Hordeum jubatum L.*	Foxtail Barley
Koeleria macrantha (Ledeb.)J.A. Schultes f.	June Grass
Muhlenbergia cuspidata (Torr.) Rydb.	Muhly Grass
Oryzopsis hymenoides (R.& S.) Ricker	Indian Rice Grass
Phleum pratense L.*	Timothy
Poa compressa L.*	Canada Bluegrass
Poa palustris L.	Fowl Bluegrass
Poa pratensis L.	Kentucky Bluegrass
Stipa comata Trin. & Rupr.	Needle and Thread Grass
Stipa curtiseta (A.S. Hitchc.) Barkworth	Western Porcupine Grass
Stipa viridula Trin.	Green Needle Grass

Cyperaceae	**Sedge Family**
Carex filifolia Nutt.	Thread-leaved Sedge
Carex obtusata Lilj.	Blunt Sedge
Juncaceae	**Rush Family**
Juncus balticus Willd.	Wire Rush
Liliaceae	**Lily Family**
Allium cernuum Roth	Nodding Onion
Allium textile Nels. & Macbr.	Prairie Onion
Disporum trachycarpum (S. Wats.) B.& H.**	Fairy-bells
Fritillaria pudica (Pursh) Spreng.	Yellow-bell
Smilacina stellata (L.) Desf.	Star-flowered Solomon's-seal
Zigadenus elegans Pursh	White Camas
Zigadenus venenosus S. Wats	Death Camas
Iridaceae	**Iris Family**
Sisyrinchium montanum Greene	Blue-eyed Grass
Orchidaceae	**Orchid Family**
Coeloglossum viride (L.) R. Br.	Bracted Orchid
Salicaceae	**Willow Family**
Populus angustifolia James	Narrow-leaf Cottonwood
Populus tremuloides Michx.	Aspen
Betulaceae	**Birch Family**
Alnus sp.	Alder
Betula occidentalis Hook.	Water Birch; Black Birch
Santalaceae	**Sandalwood Family**
Comandra umbellata (L.) Nutt.	Bastard Toadflax
Polygonaceae	**Buckwheat Family**
Eriogonum flavum Nutt.	Yellow Umbrella-plant
Nyctaginaceae	**Four-o'clock Family**
Mirabilis hirsuta (Pursh) MacM.	Umbrellawort
Caryophyllaceae	**Pink Family**
Cerastium arvense L.	Mouse-ear Chickweed
Moehringia lateriflora (L.) Fenzl.	Sandwort
Paronychia sessiliflora Nutt.	Low Whitlow-wort
Silene noctiflora L.*	Night-flowering Catchfly
Ranunculaceae	**Crowfoot Family**
Anemone cylindrica A. Gray	Long-fruited Anemone
Anemone multifida Poir.	Cut-leaved Anemone

Anemone patens L.	Prairie Crocus
Clematis ligusticifolia Nutt.	Western Clematis
Delphinium bicolor Nutt.	Low Larkspur
Thalictrum venulosum Trel.	Veiny Meadow-rue
Cruciferae	**Mustard Family**
Arabis divaricarpa L.	Rock Cress
Arabis nuttallii Robinson	Rock Cress
Conringia orientalis (L.) Dum.*	Hare's-ear Mustard
Erysimum cheiranthoides L.*	Wormseed Mustard
Erysimum inconspicuum (S. Wats.) MacM.	Small-flowered Rocket
Lesquerella arenosa (Richards.) Rydb.	Bladder-pod
Physaria didymocarpa (Hook.) A. Gray	Double Bladder-pod
Thlaspi arvense L.*,**	Pennycress; Stinkweed
Saxifragaceae	**Saxifrage Family**
Heuchera parvifolia Nutt. ex T. & G.	Alum-root
Grossulariaceae	**Gooseberry Family**
Ribes hirtellum Michx.**	Wild Gooseberry
Ribes oxyacanthoides L.	Wild Gooseberry
Rosaceae	**Rose Family**
Amelanchier alnifolia Nutt.	Saskatoon
Chamaerhodos erecta (L.) Bunge	Chamaerhodos
Crataegus douglasii Lindl.	Douglas Hawthorn
Crataegus rotundifolia Moench	Round-leaf Hawthorn
Fragaria virginiana Duchesne	Wild Strawberry
Geum allepicum Jacq.	Yellow Avens
Geum triflorum Pursh	Three-flowered Avens
Potentilla anserina L.	Silverweed
Potentilla concinna Richards.	Early Cinquefoil
Potentilla fruticosa L.	Shrubby Cinquefoil
Potentilla gracilis Dougl. ex Hook.	Graceful Potentilla
Potentilla hippiana Lehm.	Wooly Cinquefoil
Potentilla pensylvanica L.	Prairie Cinquefoil
Prunus virginiana L.	Choke Cherry
Rosa acicularis Lindl.	Prickly Rose
Rosa arkansana Porter	Prairie Rose
Rosa woodsii Lindl.	Common Wild Rose
Leguminosae	**Pea Family**
Astragalus bisulcatus (Hook.) A. Gray	Two-grooved Milk Vetch
Astragalus crassicarpus Nutt.	Ground Plum
Astragalus dasyglottis Fisch. ex DC.	
Astragalus drummondii Dougl. ex Hook.	Drummond's Milk Vetch
Astragalus flexuosus Dougl.	Slender Milk Vetch
Astragalus gilviflorus Sheldon	Cushion Milk Vetch

Astragalus missouriensis Nutt.	Missouri Milk Vetch
Astragalus pectinatus Dougl. ex Hook.	Narrow-leaved Milk Vetch
Astragalus tenellus Pursh	Loose-flowered Milk Vetch
Astragalus vexilliflexus Sheldon	Bent-flowered Milk Vetch
Glycyrrhiza lepidota (Nutt.) Pursh	Wild Licorice
Hedysarum alpinum L.	American Sweetbroom
Hedysarum boreale Nutt.	Northern Hedysarum
Hedysarum sulphurescens Rydb.	Yellow Hedysarum
Lupinus argenteus Pursh	Perennial Lupine
Lupinus sericeus Pursh	Perennial Lupine
Medicago sativa L.*	Alfalfa
Melilotus alba Desr.*	White Sweet Clover
Melilotus officinalis (L.) Lam.*	Yellow Sweet Clover
Oxytropis monticola A. Gray	Late Yellow Loco-weed
Oxytropis sericea Nutt.	Early Yellow Loco-weed
Oxytropis splendens Dougl. ex Hook.	Showy Locoweed
Petalostemon candidum (Willd.) Michx.	White Prairie Clover
Petalostemon purpureum (Vent.) Rydb.	Purple Prairie Clover
Psoralea esculenta Pursh	Indian Bread-root
Thermopsis rhombifolia (Nutt.) Richards.	Buffalo Bean
Vicia americana Muhl.	Wild Vetch
Geraniaceae	**Geranium Family**
Geranium viscosissimum Fisch. & Mey.	Sticky Purple Geranium
Linaceae	**Flax Family**
Linum lewisii Pursh	Wild Blue Flax
Linum rigidum Pursh	Yellow Flax
Anacardiaceae	**Sumach Family**
Rhus trilobata Nutt.	Skunk-bush
Malvaceae	**Mallow Family**
Sphaeralcea coccinea (Pursh) Rydb.	Scarlet Mallow
Violaceae	**Violet Family**
Viola adunca J.E. Smith	Early Blue Violet
Viola canadensis L.	Western Canada Violet
Viola nuttallii Pursh	Yellow Prairie Violet
Viola renifolia A. Gray**	Kidney-leaved Violet
Loasaceae	**Loasa Family**
Mentzelia decapetala (Sims) Urban & Gilg	Evening Star
Cactaceae	**Cactus Family**
Coryphantha vivipara (Nutt.) Britt. & Rose	Cushion; Ball Cactus
Opuntia polycantha Haw.	Prickly Pear
Elaeagnaceae	**Oleaster Family**

Elaeagnus commutata Bernh. ex Rydb.	Wolf Willow
Shepherdia argentea Nutt.**	Thorny Buffalo-berry
Shepherdia canadensis (L.) Nutt.	Canadian Buffalo-berry
Onagraceae	**Evening Primrose Family**
Gaura coccinea Pursh	Scarlet Butterfly-weed
Oenothera biennis L.	Yellow Evening Primrose
Oenothera nuttallii Sweet**	White Evening Primrose
Umbelliferae	**Carrot Family**
Heracleum lanatum Michx.**	Cow Parsnip
Lomatium triternatum (Pursh) Coult. & Rose	Prairie Parsley
Musineon divaricatum (Pursh) Nutt.	Leafy Musineon
Zizia aptera (A. Gray) Fern.	Meadow Parsnip, Heartleafed Alexanders
Osmorhiza chilensis Hook. & Arn.**	Sweet Cicely
Perideridia gairdneri (Hook. & Arn.) Mathius	Squaw Root, Yampa
Cornaceae	**Dogwood Family**
Cornus stolonifera Michx.	Red-osier Dogwood
Ericaceae	**Heath Family**
Arctostaphylos uva-ursi (L.) Spreng	Common Bearberry, Kinnickinnick
Primulaceae	**Primrose Family**
Androsace chamaejasme Host	Sweet-flowered Androsace
Androsace occidentalis Pursh	Fairy Candelabra
Androsace septentrionalis L.	Fairy Candelabra
Dodecatheon conjugens Greene	Shooting Star
Gentianaceae	**Gentian Family**
Gentianella amarella (L.) Borner	Felwort
Apocynaceae	**Dogbane Family**
Apocynum androsaemifolium L.	Spreading Dogbane
Apocynum cannabinum L.**	Indian Hemp
Polemoniaceae	**Phlox Family**
Collomia linearis Nutt.	Collomia
Phlox hoodii Richards	Moss Phlox
Polemonium pulcherrimum Hook.	Jacobs-ladder
Boraginaceae	**Borage Family**
Cryptantha nubigena (Greene) Payson	CLustered Oreocarya
Cynoglossum officinale L.*	Hound's-tongue
Hackelia floribunda (Lehm.) I.M. Johnston	Stick-seed
Lappula occidentalis (S. Wats.) Greene*	Stick-tights
Lappula squarrosa Moench*	Beggar-ticks

Lithospermum incisum Lehm.	Puccoon
Lithospermum ruderale Lehm.	Yellow Puccoon
Labiatae	**Mint Family**
Mentha arvensis L.	Wild Mint
Monarda fistulosa L.	Wild Bergamot
Stachys palustris L.**	Hedge Nettle
Scrophulariaceae	**Figwort Family**
Besseya wyomingensis (A. Nels) Rydb.	Kitten-tails
Castilleja lutescens (Greenm.) Rydb.	Yellow Indian Paint-brush
Orthocarpus luteus Nutt.	Owl-clover
Penstemon confertus Dougl.	Yellow Beard-tongue
Penstemon eriantherus Pursh	Crested Beard-tongue
Penstemon nitidus Dougl. ex Benth.	Smooth Blue Beard-tongue
Penstemon procerus Dougl. ex Grah.	Slender Blue Beard-tongue
Orobanchaceae	**Broom-rape Family**
Orobanche fasciculata Nutt.	Clustered Broom-rape
Plantaginaceae	**Plantain Family**
Plantago canescens Adams	Plantain
Rubiaceae	**Madder Family**
Galium boreale L.	Northern Bedstraw
Caprifoliaceae	**Honeysuckle Family**
Symphoricarpos albus (L.) Blake**	Snowberry
Symphoricarpos occidentalis Hook.	Buckbrush
Campanulaceae	**Bluebell Family**
Campanula rotundifolia L.	Bluebell; Harebell
Compositae	**Composite Family**
Achillea millefolium L.	Common Yarrow
Agoseris glauca (Pursh) Raf	False Dandelion
Antennaria anaphaloides Rydb.	Pussy Toes, Tall Everlasting
Antennaria parvifolia Nutt.	Pussy Toes, Small-leaved Everlasting
Antennaria rosea Greene	Pink Pussy Toes
Arnica fulgens Pursh**	Shining Arnica
Arnica sororia Greene	Twin Arnica
Artemisia campestris L.	Field Sage
Artemisia dracunculus L.**	Dragonwort
Artemisia frigida Willd.	Pasture Sage
Artemisia ludoviciana Nutt.	Prairie Sage
Aster conspicuus Lindl.**	Showy Aster
Aster ericoides L.	Tufted White Prairie Aster
Aster falcatus Lindl.	Creeping White Prairie Aster

Aster laevis L.	Smooth Aster
Balsamorhiza sagittata (Pursh) Nutt.	Balsam-root
Cirsium arvense (L.) Scop.*	Canada Thistle
Cirsium undulatum (Nutt.) Spreng.	Wavy-leaved Thistle
Erigeron caespitosus Nutt.	Tufted Fleabane
Erigeron compositus Pursh	Compound Fleabane
Erigeron glabellus Nutt.	Smooth Fleabane
Erigeron speciosus (Lindl.) DC.	Showy Fleabane
Gaillardia aristata Pursh	Gaillardia; Blanket Flower
Grindelia squarrosa (Pursh) Dunal	Gumweed
Gutierrezia sarothrae (Pursh) Britt. & Rusby	Broomweed
Haplopappus lanceolatus (Hook.) T. & G.**	Lance-leaved Pyrrocoma
Haplopappus spinulosus (Pursh) DC.	Spiny Ironplant
Helianthus annuus L.	Common Annual Sunflower
Helianthus subrhomboideus Rydb.	Rhombic-leaved Sunflower
Heterotheca villosa (Pursh) Shinners	Golden Aster
Hymenopappus filifolius Hook.	Tufted Hymenopappus
Hymenoxys acaulis (Pursh) Parker	Stemless Rubberweed
Hymenoxys richardsonii (Hook.) Cockerell	Colorado Rubber-plant
Liatris punctata Hook.	Dotted Blazing Star
Lygodesmia juncea (Pursh) D. Don	Skeleton-weed
Ratibida columnifera (Nutt.) Wooten & Standl.	Prairie Cone-flower
Senecio canus Hook.	Prairie Groundsel
Senecio integerrimus Nutt.	Entire-leaved Groundsel
Solidago missouriensis Nutt.	Missouri Goldenrod
Solidago rigida L.	Stiff Goldenrod
Taraxacum officinale Weber*	Dandelion
Townsendia exscapa (Richards.) Porter	Townsendia
Tragapogon dubius Scop.*	Goat's-beard
Xanthium strumarium L.*	Cocklebur

Appendix III. Voucher specimens collected (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
AS098	*Achillea millefolium*	07-06-90	S19-R29-Twp7-W4
AS141	*Achillea millefolium*	18-06-90	S11-R1-Twp7-W5
JH158	*Agoseris glauca*	26-06-90	S16-R29-Twp7-W4
AS136	*Agropyon spicatum*	14-06-90	S32-R1-Twp7-W5
AS199	*Agropyron dasystachyum*	09-08-90	S32-R1-Twp7-W4
AS111	*Agropyron smithii*	08-06-90	S16-R29-Twp7-W4
AS137	*Agropyron smithii*	14-06-90	S32-R1-Twp7-W5
AS191	*Agropyron smithii*	09-08-90	S32-R1-Twp7-W4
AS011	*Agropyron spicatum*	18-07-89	S32-R1-Twp7-W5
AS193	*Agropyron spicatum*	09-08-90	S32-R1-Twp7-W4
AS135	*Agropyron trachycaulum?*	14-06-90	S32-R1-Twp7-W5
AS198	*Agropyron trachycaulum?*	09-08-90	S32-R1-Twp7-W4
AS003	*Allium cernuum*	18-07-89	S32-R1-Twp7-W5
JH181	*Allium cernuum*	20-07-90	S19-R29-Twp7-W4
AS184	*Allium cernuum*	09-08-90	S32-R1-Twp7-W4
AS071	*Allium textile*	28-06-90	S16-R29-Twp7-W4
AS090	*Androsace occidentalis*	07-06-90	S24-R1-Twp7-W5
AS065	*Anemone multifida*	28-06-90	S16-R29-Twp7-W4
AS094	*Antennaria anaphaloides*	07-06-90	S19-R29-Twp7-W4
AS054	*Antennaria parvifolia*	28-06-90	S11-R1-Twp7-W5
AS014	*Antennaria parvifolia*	18-07-89	S32-R1-Twp7-W5
AS049	*Antennaria rosea*	28-06-90	S11-R1-Twp7-W5
JH178	*Apocynum androsaemifolium*	19-07-90	S16-R29-Twp7-W4
AS082	*Arabis divaricarpa*	06-06-90	S32-R1-Twp7-W5
AS100	*Arabis divaricarpa*	07-06-90	S19-R29-Twp7-W4
AS038	*Arabis nuttallii*	06-06-90	S32-R1-Twp7-W5
AS081	*Arabis nuttallii*	06-06-90	S32-R1-Twp7-W5

Appendix III. Voucher specimens collected (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
AS099	*Arabis nuttallii*	07-06-90	S19-R29-Twp7-W4
AS055	*Arabis nuttallii*	28-06-90	S11-R1-Twp7-W5
AS031	*Arabis nuttallii*	06-06-90	S32-R1-Twp7-W5
AS140	*Arnica sororia*	14-06-90	S32-R1-Twp7-W5
AS188	*Artemisia campestris*	09-08-90	S32-R1-Twp7-W4
JH213	*Artemisia campestris*	27-08-90	S17-R29-Twp7-W4
AS215	*Aster ericoides*	27-08-90	S17-R29-Twp7-W4
AS186	*Aster laevis*	09-08-90	S32-R1-Twp7-W4
JH214	*Aster laevis*	27-08-90	S17-R29-Twp7-W4
AS142	*Astragalus bisulcatus*	18-06-90	S11-R1-Twp7-W5
AS068	*Astragalus crassicarpus*	28-06-90	S16-R29-Twp7-W4
AS109	*Astragalus drummondii*	08-06-90	S16-R29-Twp7-W4
AS119	*Astragalus flexuosus*	12-06-90	S17-R29-Twp7-W4
AS020	*Astragalus gilviflorus*	06-06-90	S33-R1-Twp7-W5
AS073	*Astragalus missouriensis*	28-06-90	S16-R29-Twp7-W4
AS021	*Astragalus missouriensis*	06-06-90	S16-R29-Twp7-W4
AS106	*Astragalus pectinatus*	08-06-90	S16-R29-Twp7-W4
AS107	*Astragalus striatus?*	08-06-90	S16-R29-Twp7-W4
AS168	*Astragalus striatus?*	28-06-90	S16-R29-Twp7-W4
AS102	*Astragalus tenellus*	07-06-90	S19-R29-Twp7-W4
AS057	*Astragalus tenellus*	28-06-90	S16-R29-Twp7-W4
AS077	*Astragalus vexilliflexus*	06-06-90	S24-R1-Twp7-W5
AS074	*Astragalus vexilliflexus*	28-06-90	S16-R29-Twp7-W4
AS030	*Balsamorhiza sagittata*	06-06-90	S16-R29-Twp7-W4
AS029	*Besseya wyomingensis*	06-06-90	S33-R1-Twp7-W5
AS138	*Besseya wyomingensis*	14-06-90	S32-R1-Twp7-W5
AS133	*Betula occidentalis*	14-06-90	S16-R29-Twp7-W4

Appendix III. Voucher specimens collected (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
AS203	*Bouteloua gracilis*	10-08-90	S16-R29-Twp7-W4
AS072	*Calamagrostis montanensis?*	28-06-90	S16-R29-Twp7-W4
JH159	*Campanula rotundifolia*	26-06-90	S16-R29-Twp7-W4
AS078	*Carex filifolia*	06-06-90	S24-R1-Twp7-W5
AS032	*Carex obtusata*	06-06-90	S33-R1-Twp7-W5
AS008	*Carex* sp.	18-07-89	S32-R1-Twp7-W5
AS009	*Carex* sp.	18-07-89	S32-R1-Twp7-W5
AS096	*Castilleja lutescens*	07-06-90	S19-R29-Twp7-W4
AS037	*Cerastium arvense*	06-06-90	S33-R1-Twp7-W5
AS041	*Cerastium arvense*	28-06-90	S11-R1-Twp7-W5
AS087	*Chamaerhodos erecta*	07-06-90	S19-R29-Twp7-W4
JH179	*Clematis ligusticifolia*	19-07-90	S16-R29-Twp7-W4
AS122	*Coeloglossum viride*	14-06-90	S16-R1-Twp7-W4
AS043	*Comandra umbellata*	28-06-90	S11-R1-Twp7-W5
AS002	*Conringia orientalis*	29-06-89	S32-R1-Twp7-W4
AS165	*Cornus stolonifera*	28-06-90	S16-R29-Twp7-W4
AS105	*Crataegus rotundifolia*	08-06-90	S16-R29-Twp7-W4
AS110	*Crucifer* (weed)	08-06-90	S16-R29-Twp7-W4
AS085	*Cryptantha nubigena*	07-06-90	S19-R29-Twp7-W4
AS069	*Cryptantha nubigena*	28-06-90	S16-R29-Twp7-W4
AS134	*Cystopteris fragilis*	14-06-90	S16-R29-Twp7-W4
AS125	*Danthonia parryi*	14-06-90	S16-R29-Twp7-W4
AS192	*Danthonia parryi*	09-08-90	S32-R1-Twp7-W4
AS023	*Delphinium bicolor*	06-06-90	S16-R29-Twp7-W4
AS060	*Delphinium bicolor*	28-06-90	S16-R29-Twp7-W4
AS025	*Dodecatheon conjugens*	06-06-90	S32-R1-Twp7-W5

Appendix III. Voucher specimens collected (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
AS123	*Elaeagnus commutata*	14-06-90	S16-R29-Twp7-W4
AS004	*Elymus piperi*	18-07-89	S16-R29-Twp7-W4
JH175	*Erigeron caespitosus*	19-07-90	S16-R29-Twp7-W4
AS190	*Erigeron caespitosus*	09-08-90	S32-R1-Twp7-W4
JH182	*Erigeron speciosus*	20-07-90	S19-R29-Twp7-W4
AS152	*Eriogonum flavum*	21-06-90	S17-R29-Twp7-W4
AS084	*Erysimum cheiranthoides*	07-06-90	S19-R29-Twp7-W4
AS115	*Festuca saximontana*?	08-06-90	S16-R29-Twp7-W4
AS195	*Festuca saximontana*?	09-08-90	S32-R1-Twp7-W4
AS101	*Festuca campestris* ?	07-05-90	S19-R29-Twp7-W4
AS080	*Festuca campestris*	06-06-90	S24-R1-Twp7-W5
AS092	*Festuca campestris*	07-06-90	S19-R29-Twp7-W4
AS114	*Festuca campestris*	08-06-90	S16-R29-Twp7-W4
AS075	*Festuca campestris*	28-06-90	S16-R29-Twp7-W4
AS056	*Festuca campestris*	28-06-90	S16-R29-Twp7-W4
AS196	*Festuca campestris*	09-08-90	S32-R1-Twp7-W4
AS034	*Festuca campestris*?	06-06-90	S32-R1-Twp7-W5
AS036	*Festuca campestris?*	06-06-90	S16-R29-Twp7-W4
AS051	*Fragaria virginiana*	28-06-90	S11-R1-Twp7-W5
AS026	*Fritillaria pudica*	06-06-90	S16-R29-Twp7-W4
AS150	*Gaillardia aristata*	21-06-90	S17-R29-Twp7-W4
JH177	*Galium boreale*	19-07-90	S16-R29-Twp7-W4
AS162	*Gaura coccinea*	27-06-90	S19-R29-Twp7-W4
AS167	*Gaura coccinea*	28-06-90	S16-R29-Twp7-W4
AS209	*Gentianella amarella*	10-08-90	S19-R29-Twp7-W4
AS121	*Geranium viscosissimum*	12-06-90	S17-R29-Twp7-W4
AS027	*Geum triflorum*	06-06-90	S33-R1-Twp7-W5

Appendix III. Voucher specimens collected (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
AS045	*Geum triflorum*	28-06-90	S11-R1-Twp7-W5
AS128	Grass sp.	14-06-90	S16-R29-Twp7-W4
AS211	*Poa palustris*	10-08-90	S19-R29-Twp7-W4
AS205	*Grindelia squarrosa*	10-08-90	S16-R29-Twp7-W4
AS216	*Gutierrezia sarothrae*	27-08-90	S17-R29-Twp7-W4
AS079	*Hackelia floribunda*	06-06-90	S24-R1-Twp7-W5
AS089	*Hackelia floribunda*	07-06-90	S19-R29-Twp7-W4
JH212	*Haplopappus spinulosus*	27-08-90	S17-R29-Twp7-W4
AS130	*Hedysarum alpinum*	14-06-90	S16-R29-Twp7-W4
AS129	*Hedysarum sulphurescens*	14-06-90	S16-R29-Twp7-W4
AS067	*Hedysarum sulphurescens*	28-06-90	S16-R29-Twp7-W4
JH183	*Helianthus annuus*	20-07-90	S17-R29-Twp7-W4
JH174	*Helianthus subrhomboideus*	19-07-90	S16-R29-Twp7-W4
JH172	*Heterotheca villosa*	19-07-90	S16-R29-Twp7-W4
AS118	*Heuchera parvifolia*	08-06-90	S27-R30-Twp7-W4
AS066	*Hymenoxys acaulis*	28-06-90	S16-R29-Twp7-W4
JH157	*Hymenoxys richarsonii*	26-06-90	S16-R29-Twp7-W4
AS153	*Koeleria macrantha*	21-06-90	S17-R29-Twp7-W4
AS035	*Koeleria macrantha?*	06-06-90	S16-R29-Twp7-W4
AS093	*Koeleria macrantha?*	07-06-90	S19-R29-Twp7-W4
AS112	*Koeleria macrantha*	08-06-90	S16-R29-Twp7-W4
AS048	*Lesqerella arenosa*	28-06-90	S11-R1-Twp7-W5
AS197	*Liatris punctata*	09-08-90	S32-R1-Twp7-W4
AS217	*Liatris punctata*	27-08-90	S17-R29-Twp7-W4
AS086	*Linum lewisii*	07-06-90	S19-R29-Twp7-W4
AS143	*Linum lewisii*	21-06-90	S17-R29-Twp7-W4
JH155	*Linum rigidum*	26-06-90	S16-R29-Twp7-W4

Appendix III. Voucher specimens collected (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
AS058	*Lithospermum incisum*	28-06-90	S16-R29-Twp7-W4
AS046	*Lithospermum ruderale*	28-06-90	S11-R1-Twp7-W5
AS033	*Lomatium triternatum*	06-06-90	S33-R1-Twp7-W5
AS059	*Lomatium triternatum*	28-06-90	S16-R29-Twp7-W4
AS063	*Lupinus argenteus*	28-05-90	S16-R29-Twp7-W4
AS116	*Lupinus argenteus*	08-06-90	S16-R29-Twp7-W4
AS117	*Lupinus sericeus?*	08-06-90	S16-R29-Twp7-W4
AS207	*Lygodesmia juncea*	10-08-90	S16-R29-Twp7-W4
AS204	*Menztzelia decapetala*	10-08-90	S16-R29-Twp7-W4
AS132	*Moehringia lateriflora*	14-06-90	S16-R29-Twp7-W4
JH170	*Monarda fistulosa*	19-07-90	S16-R29-Twp7-W4
AS202	*Muhlenbergia cuspidata*	09-08-90	S16-R29-Twp7-W4
AS019	*Musineon divaricatum*	06-06-90	S33-R1-Twp7-W5
AS050	*Musineon divaricatum*	28-06-90	S11-R1-Twp7-W5
AS145	*Orobanche fasciculata*	21-06-90	S17-R29-Twp7-W4
JH176	*Orthocarpus luteus*	19-07-90	S16-R29-Twp7-W4
AS187	*Orthocarpus luteus*	09-08-90	S32-R1-Twp7-W4
AS163	*Oryzopsis hymenoides*	27-06-90	S19-R29-Twp7-W4
AS091	*Oxytropis sericea*	07-06-90	S19-R29-Twp7-W4
AS053	*Oxytropis sericea*	28-06-90	S11-R1-Twp7-W5
AS146	*Paronychia sessiliflora*	21-06-90	S17-R29-Twp7-W4
AS139	*Penstemon confertus*	14-06-90	S32-R1-Twp7-W5
AS001	*Penstemon eriantherus*	14-06-89	S17-R29-Twp7-W4
AS120	*Penstemon eriantherus*	12-06-90	S17-R29-Twp7-W4
AS088	*Penstemon nitidus*	07-06-90	S19-R29-Twp7-W4
AS047	*Penstemon nitidus*	28-06-90	S11-R1-Twp7-W5
AS208	*Perideridia gairdneri*	10-08-90	S19-R29-Twp7-W4

Appendix III. Voucher specimens collected (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
JH169	*Petalostemon candidum*	19-07-90	S16-R29-Twp7-W4
JH173	*Petalostemon purpureum*	19-07-90	S16-R29-Twp7-W4
AS185	*Petalostemon purpureum*	09-08-90	S32-R1-Twp7-W4
AS028	*Phlox hoodii*	06-06-90	S33-R1-Twp7-W5
AS024	*Physaria didymocarpa*	06-06-90	S16-R29-Twp7-W4
AS070	*Physaria didymocarpa*	28-06-90	S16-R29-Twp7-W4
AS131	*Plantago canescens*	14-06-90	S16-R29-Twp7-W4
AS200	*Poa compressa*	09-08-90	S16-R29-Twp7-W4
AS005	*Poa pratensis*	18-07-89	S16-R29-Twp7-W4
AS042	*Poa pratensis?*	28-06-90	S11-R1-Twp7-W5
AS052	*Poa pratensis?*	28-06-90	S11-R1-Twp7-W5
AS194	*Poa pratensis?*	09-08-90	S32-R1-Twp7-W4
AS113	*Poa* sp.	08-06-90	S16-R29-Twp7-W4
AS076	*Polemonium pulcherrimum*	06-06-90	S24-R1-Twp7-W5
AS164	*Populus angusticifolia*	28-06-90	S16-R29-Twp7-W4
AS040	*Potentilla concinna*	06-06-90	S33-R1-Twp7-W5
JH156	*Potentilla fruticosa*	26-06-90	S16-R29-Twp7-W4
AS149	*Potentilla hippiana*	21-06-90	S17-R29-Twp7-W4
AS013	*Potentilla hippiana*	18-07-89	S16-R29-Twp7-W4
AS151	*Potentilla pensylvanica*	21-06-90	S17-R29-Twp7-W4
AS161	*Potentilla pensylvanica*	27-06-90	S19-R29-Twp7-W4
AS012	*Potentilla pensylvanica*	18-07-89	S16-R29-Twp7-W4
AS104	*Prunus virginiana*	08-06-90	S16-R29-Twp7-W4
AS147	*Psoralea esculenta*	21-06-90	S17-R29-Twp7-W4
JH180	*Ratibida columnifera*	20-07-90	S19-R29-Twp7-W4
AS062	*Rhus trilobata*	28-06-90	S16-R29-Twp7-W4
AS126	*Rosa arkansana*	14-06-90	S16-R29-Twp7-W4

Appendix III. Voucher specimens collected (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
AS166	*Rosa arkansana*	28-06-90	S33-R1-Twp7-W5
AS097	*Senecio canus*	07-06-90	S19-R29-Twp7-W4
AS064	*Senecio canus*	28-06-90	S16-R29-Twp7-W4
AS083	*Senecio integerrimus*	07-06-90	S19-R29-Twp7-W4
AS044	*Shepherdia canadensis*	28-06-90	S11-R1-Twp7-W5
JH160	*Sisyrinchium montanum*	26-06-90	S16-R29-Twp7-W4
AS061	*Smilacina stellata*	28-06-90	S16-R29-Twp7-W4
AS006	*Solidago missouriensis*	13-07-89	S11-R1-Twp7-W5
AS007	*Solidago missouriensis*	18-07-89	S16-R29-Twp7-W5
JH171	*Solidago missouriensis*	19-07-90	S16-R29-Twp7-W4
AS189	*Solidago missouriensis*	09-08-90	S32-R1-Twp7-W4
AS206	*Solidago missouriensis*	10-08-90	S16-R29-Twp7-W4
AS144	*Sphaeralcea coccinea*	21-06-90	S17-R29-Twp7-W4
AS154	*Stipa comata*	21-06-90	S17-R29-Twp7-W4
AS010	*Stipa comata*	18-07-89	S32-R1-Twp7-W5
AS201	*Stipa comata*	09-08-90	S16-R29-Twp7-W4
AS210	*Symphoricarpos occidentalis*	10-08-90	S19-R29-Twp7-W4
AS039	*Thermopsis rhombifolia*	06-06-90	S33-R1-Twp7-W5
AS148	*Vicia americana*	21-06-90	S17-R29-Twp7-W4
AS103	*Viola adunca*	07-06-90	S19-R29-Twp7-W4
AS218	*Viola canadensis*	28-05-90	S16-R29-Twp7-W4
AS022	*Viola nuttallii*	06-06-90	S16-R29-Twp7-W4
AS108	*Viola nuttallii*	08-06-90	S16-R29-Twp7-W4
AS127	*Zigadenus elegans*	14-06-90	S16-R29-Twp7-W4
AS095	*Zigadenus venenosus*	07-06-90	S19-R29-Twp7-W4
AS124	*Zizia aptera*	14-06-90	S16-R29-Twp7-W4

Appendix IV. Native seed collection (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
88	*Agoseris glauca*	06-06-90	S19-R29-Twp7-W4
100	*Agropyron smithii*	09-08-90	S32-R1-Twp7-W5
98	*Agropyron spicatum*	09-08-90	S32-R1-Twp7-W5
140	*Allium cernuum*	27-08-90	S16-R29-Twp7-W4
79	*Allium textile*	19-07-90	S16-R29-Twp7-W4
65	*Allium textile*	21-07-90	S17-R29-Twp7-W4
89	*Anemone multifida*	19-07-90	S16-R29-Twp7-W4
164	*Anemone patens*	07-06-90	S19-R29-Twp7-W4
47	*Antennaria parvifolia*	27-06-90	S17-R29-Twp7-W4
150	*Aster laevis*	27-08-90	S16-R29-Twp7-W4
60	*Astragalus drummondii*	21-07-90	S16-R29-Twp7-W4
132	*Astragalus drummondii*	10-08-90	S16-R29-Twp7-W4
62	*Astragalus flexuosus*	21-07-90	S17-R29-Twp7-W4
122	*Astragalus flexuosus*	09-08-90	S32-R1-Twp7-W5
149	*Astragalus gilvaflorus*	27-08-90	S17-R29-Twp7-W4
86	*Astragalus missouriensis*	10-07-90	S16-R29-Twp7-W4
76	*Astragalus missouriensis*	19-07-90	S16-R29-Twp7-W4
61	*Astragalus missouriensis*	21-07-90	S16-R29-Twp7-W4
67	*Astragalus missouriensis*	21-07-90	S17-R29-Twp7-W4
131	*Astragalus missouriensis*	10-08-90	S16-R29-Twp7-W4
118	*Astragalus pectinatus*	08-08-90	S19-R29-Twp7-W4
120	*Astragalus striatus*	08-08-90	S19-R29-Twp7-W4
128	*Astragalus striatus*	09-08-90	S17-R29-Twp7-W4
153	*Astragalus striatus*	27-08-90	S16-R29-Twp7-W4
87	*Astragalus tenellus*	19-07-90	S16-R29-Twp7-W4
48	*Balsamorhiza sagittata*	27-06-90	S17-R29-Twp7-W4
53	*Balsamorhiza sagittata*	27-06-90	S16-R29-Twp7-W4

Appendix IV. Native seed collection (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
59	*Balsamorhiza sagittata*	28-06-90	S16-R29-Twp7-W4
85	*Balsamorhiza sagittata*	10-07-90	S17-R29-Twp7-W4
113	*Besseya wyomingensis*	08-08-90	S19-R29-Twp7-W4
134	*Campanula rotundifolia*	10-08-90	S16-R29-Twp7-W4
114	*Castilleja lutescens*	08-08-90	S19-R29-Twp7-W4
108	*Cirsium undulatum*	09-08-90	S32-R1-Twp7-W5
155	*Clematis ligusticifolia*	27-08-90	S16-R29-Twp7-W4
125	*Danthonia parryi*	09-08-90	S32-R1-Twp7-W5
46	*Dodecatheon conjugens*	27-06-90	S34-R30-Twp7-W4
82	*Eriogonum flavum*	19-07-90	S16-R29-Twp7-W4
163	*Festuca campestris*	28-06-90	S16-R29-Twp7-W4
52	*Fritillaria pudica*	27-06-90	S16-R29-Twp7-W4
54	*Fritillaria pudica*	27-06-90	S17-R29-Twp7-W4
69	*Fritillaria pudica*	10-07-90	S16-R29-Twp7-W4
105	*Gaillardia aristata*	09-08-90	S32-R1-Twp7-W5
152	*Gaillardia aristata*	27-08-90	S17-R29-Twp7-W4
137	*Galium boreale*	27-08-90	S16-R29-Twp7-W4
49	*Geum triflorum*	27-06-90	S17-R29-Twp7-W4
58	*Geum triflorum*	28-06-90	S33-R1-Twp7-W5
148	*Glycyrrhiza lepidota*	27-08-90	S16-R29-Twp7-W4
157	*Haplopappus spinulosus*	27-08-90	S17-R29-Twp7-W4
141	*Hedysarum boreale*	27-08-90	S16-R29-Twp7-W4
156	*Helianthus annuus*	27-08-90	S17-R29-Twp7-W4
143	*Helianthus nuttallii*	27-08-90	S16-R29-Twp7-W4
144	*Heterotheca villosa*	27-08-90	S17-R29-Twp7-W4
107	*Heuchera parvifolia*	08-08-90	S19-R29-Twp7-W4
99	*Heuchera parvifolia*	09-08-90	S32-R1-Twp7-W5

Appendix IV. Native seed collection (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
71	*Hymenoxys acaulis*	21-07-90	S17-R29-Twp7-W4
166	*Koeleria macrantha*	28-06-90	S33-R1-Twp7-W5
138	*Liatris punctata*	27-08-90	S17-R29-Twp7-W4
170	*Liatris punctata*	26-09-90	S19-R29-Twp7-W4
172	*Liatris punctata*	26-09-90	S16-R29-Twp7-W4
77	*Linum lewisii*	19-07-90	S16-R29-Twp7-W4
92	*Linum lewisii*	19-07-90	S16-R29-Twp7-W4
75	*Linum lewisii*	21-07-90	S17-R29-Twp7-W4
116	*Linum lewisii*	08-08-90	S19-R29-Twp7-W4
121	*Linum lewisii*	08-08-90	S11-R1-Twp7-W5
70	*Linum rigidum*	21-07-90	S17-R29-Twp7-W4
123	*Linum rigidum*	09-08-90	S32-R1-Twp7-W5
50	*Lithospermum ruderale*	27-06-90	S16-R29-Twp7-W4
57	*Lithospermum ruderale*	28-06-90	S16-R29-Twp7-W4
94	*Lithospermum ruderale*	10-07-90	S17-R29-Twp7-W4
115	*Lithospermum ruderale*	08-08-90	S19-R29-Twp7-W4
51	*Lomatium triternatum*	27-06-90	S34-R30-Twp7-W4
95	*Lomatium triternatum*	10-07-90	S17-R29-Twp7-W4
56	*Lupinus argenteus*	27-06-90	S16-R29-Twp7-W4
91	*Lupinus argenteus*	10-07-90	S16-R29-Twp7-W4
73	*Lupinus argenteus*	19-07-90	S16-R29-Twp7-W4
83	*Lupinus argenteus* (white)	19-07-90	S16-R29-Twp7-W4
74	*Lupinus sericeus?*	10-07-90	S16-R29-Twp7-W4
80	*Lupinus sericeus?*	19-07-90	S16-R29-Twp7-W4
68	*Lupinus sericeus?*	20-07-90	S19-R29-Twp7-W4
66	*Lupinus sericeus?*	21-07-90	S17-R29-Twp7-W4

Appendix IV. Native seed collection (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
124	*Lupinus sericeus?*	08-08-90	S19-R29-Twp7-W4
104	*Lupinus sericeus?*	09-08-90	S32-R1-Twp7-W5
110	*Lupinus sericeus?*	09-08-90	S32-R1-Twp7-W5
142	*Monarda fistulosa*	27-08-90	S16-R29-Twp7-W4
154	*Monarda fistulosa*	27-08-90	S16-R29-Twp7-W4
112	*Orobanche fasiculata*	08-08-90	S19-R29-Twp7-W4
81	*Oryzopsis hymenoides*	19-07-90	S16-R29-Twp7-W4
119	*Oxytropis monticola*	08-08-90	S19-R29-Twp7-W4
182	*Oxytropis sericea*	03-09-90	S33-R1-Twp7-W5
72	*Oxytropis sericea*	10-07-90	S16-R29-Twp7-W4
78	*Oxytropis sericea*	19-07-90	S16-R29-Twp7-W4
102	*Oxytropis sericea*	08-08-90	S19-R29-Twp7-W4
135	*Oxytropis sericea*	10-08-90	S16-R29-Twp7-W4
103	*Penstemon confertus*	09-08-90	S32-R1-Twp7-W5
173	*Penstemon nitidus*	09-08-90	S16-R29-Twp7-W4
130	*Penstemon nitidus*	10-08-90	S16-R29-Twp7-W4
145	*Petalostemon candidum*	27-08-90	S16-R29-Twp7-W4
93	*Potentilla hippiana*	19-07-90	S16-R29-Twp7-W4
63	*Potentilla hippiana*	21-07-90	S17-R29-Twp7-W4
106	*Potentilla hippiana*	08-08-90	S11-R1-Twp7-W5
111	*Potentilla pensylvanica*	08-08-90	S19-R29-Twp7-W4
151	*Potentilla* sp.	27-08-90	S16-R29-Twp7-W4
127	*Psoralea esculenta*	09-08-90	S17-R29-Twp7-W4
136	*Psoralea esculenta*	10-08-90	S16-R29-Twp7-W4
147	*Psoralea esculenta*	27-08-90	S16-R29-Twp7-W4
146	*Ratibida columnifera*	27-08-90	S16-R29-Twp7-W4
171	*Ratibida columnifera*	26-09-90	S16-R29-Twp7-W4

Appendix IV. Native seed collection (some identifications have yet to be verified).

Coll. No.	Taxa	Date	Location
84	*Senecio canus*	10-07-90	S16-R29-Twp7-W4
117	*Silene noctiflora*	08-08-90	S19-R29-Twp7-W4
96	*Sisyrinchium montanum*	19-07-90	S16-R29-Twp7-W4
133	*Sisyrinchium montanum*	10-08-90	S16-R29-Twp7-W4
109	*Stipa curtiseta*	09-08-90	S32-R1-Twp7-W5
129	*Stipa* sp.	10-08-90	S16-R29-Twp7-W4
126	*Stipa viridula*	31-08-90	S33-R1-Twp7-W5
64	*Thermopsis rhombifolia*	21-07-90	S24-R1-Twp7-W5
160	*Viola nuttallii*	21-06-90	S17-R29-Twp7-W4
101	*Zigadenus venenosus*	09-08-90	S32-R1-Twp7-W5